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**THE EFFECTS OF THE ENVIRONMENT ON THE HEALTH AND  
WELFARE OF GROWING PIGS**

**BY**

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Jonathan Amory



“I like pigs. Dogs look up to us. Cats look down on us. Pigs treat us as equals.”

*Sir Winston Churchill (1874-1965)*



## ABSTRACT

The welfare of pigs reared in intensive housing systems has been an increasing source of public concern. An investigation was carried out to find factors within the physical and social environment that mediate a range of behavioural and physiological indicators of welfare of growing pigs kept under commercial conditions. An initial study investigated human approach behaviour and clinical signs of disease on commercial farms. Multivariate statistical analysis identified factors that were significantly associated with these welfare indicators, particularly stockman-animal interactions, type of flooring, provision of straw bedding and air quality. This study suggested that the period immediately post-weaning may be important in behavioural development. An abattoir study looked at response to handling, behaviour in lairage, prevalence of bursitis and the prevalence of gastric ulcers post-slaughter. The results indicated the benefits of the provision of straw bedding and welfare problems of slatted flooring, supporting previous findings of a relationship between pelleted diets and increased prevalence of pars oesophageal hyperkeratosis and ulceration. The second abattoir study concentrated on pathological signs of respiratory disease and measurement of acute phase proteins. Only haptoglobin was significantly associated with signs of enzootic pneumonia at slaughter. However, models were successfully constructed for the respiratory diseases and the acute phase proteins that indicated the importance of air quality and some husbandry techniques. Two controlled experiments were carried out, one examining the importance of environmental enrichment at particular rearing stages, the other looking at the effects of alarm pheromones on piglet behaviour. The first trial demonstrated that regularly providing 0.5 kg of straw during rearing only had little effect on welfare and did not affect immune response or adrenocortical function. The second trial demonstrated that pheromones present in the urine of gilts subjected to an alarming situation were aversive to weaner piglets and could have consequences for their welfare.

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Amory, J.R. and Pearce, G.P., 1998. Effect of environmental conditions and husbandry system on signs of injury and disease in grower-finisher pigs. International Pig Veterinary Society meeting, Birmingham.

Amory, J.R. and Pearce, G.P., 1998. Effect of husbandry system on human approach behaviour in grower-finisher pigs. International Pig Veterinary Society meeting, Birmingham.

Amory, J.R. and Pearce, G.P., 1998. Effect of urinary alarm pheromones on the behaviour of young pigs. International Pig Veterinary Society meeting, Birmingham.

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## LIST OF ABBREVIATIONS

m	metre
cm	centimetre
mm	millimetre
kg	kilogram
g	gram
mg	milligram
µg	microgram
l	litre
ml	millilitre
µl	microlitre
ppm	parts per million
i.u.	international units
h	hours
min	minutes
s	seconds
rpm	revolutions per minute
°C	degrees Celcius
%	per cent
%rh	per cent relative humidity
sem / SEM	standard error of the mean
p / P	probability
NS	not significant
ln	natural logarithm
√	square root
CRP	C-reactive protein
MAP	Major Acute Phase protein
SAA	Serum Amyloid A
EP	Enzootic pneumonia
PL	Pleuropneumonia
KLH	Keyhole Limpet Haemocyanin
ACTH	adrenocorticotrophic hormone
IgG	Immunoglobulin G
OFT	open-field test
NO	novel object
HA	human approach

## **CHAPTER 1. LITERATURE REVIEW.**

The purpose of this review is to highlight and discuss current literature concerning pig welfare. In order to do so it is essential to describe what 'pig welfare' is, why it is of importance, how it is measured and what factors contribute towards poor and good welfare.

The first section entitled 'Assessment of Pig Welfare' lists the numerous definitions of 'welfare' and gives an overview of animal welfare research. It also outlines the importance of pig welfare in human society and reasons for concern in this area. The second section is a study of pig behaviour and its underlying theories. It describes methods of recording behaviour and provides an account of behaviours performed by the pig. The third and fourth sections of this review are concerned with the various physiological and behavioural indicators that scientists have used to determine animal welfare continuing the multi-disciplinary approach to animal welfare science introduced in the first section.



## 1.1 Assessment of pig welfare

### *1.1.1 The consumer, the farmer, the pig*

Red meat has always been identified as a major part of the British diet with pork increasingly being seen as a lean, healthy meal ingredient (MLC, 1997). UK pork consumption in 1996 was 800,000 tonnes (MLC, 1997).

In order to meet the demands of the consumer in the 1950's and 60's for reduced food prices farming husbandry techniques (particularly those of pigs and poultry) became more intensive (Duncan and Dawkins, 1983). Such intensification had a range of commercial advantages; 1) it allowed for ease of handling and storage of dry, cereal based feeds; 2) feed costs were reduced through control of air temperature; 3) control of infectious disease in densely stocked buildings was improved by i) vaccination, ii) antibiotics and iii) supply and maintenance of minimal disease stock (Webster, 1995). These modern farming techniques reduced the price of pig and poultry products and gave a more standardised product, making these products more attractive to the consumer and so propelling intensification (Webster 1995).

In 1964 Ruth Harrison published her book 'Animal Machines' (Harrison, 1964) which brought public attention to the intensification process and led to an increase in public concern for the welfare of intensively farmed animals (Duncan and Dawkins, 1983). Particular concerns that the book made reference to were the artificial environments

provided by some modern systems, the degree of crowding involved and the sheer scale of such units. In response to public concern the government appointed the Brambell Committee to review the welfare of farm animals in intensive husbandry systems in 1965. They proposed that all farm animals should at least have the freedom to stand up, lie down, turn around, groom themselves and stretch their limbs (Webster 1995). These became known as the five freedoms, which have since evolved with time until they were revised in 1993 (Farm Animal Welfare Council, 1993). They now state that animals should be provided with:

- i. freedom from thirst, hunger or malnutrition;
- ii. freedom from discomfort (appropriate comfort and shelter);
- iii. freedom from pain injury or disease (by the prevention, or rapid diagnosis and treatment of injury, disease or infestation);
- iv. freedom to express normal behaviour (by providing sufficient space, proper facilities and company of conspecifics).
- v. freedom from fear and distress (by ensuring conditions and treatment avoid mental suffering).

In 1967 the government established the Farm Animal Welfare Advisory Committee (FAWAC). The role of the committee was to advise the government on animals' welfare issues and make recommendations when appropriate. In 1968 a new Act of Parliament made provisions for the welfare of livestock making it unlawful to cause unnecessary pain or distress to farm animals (Agriculture (Miscellaneous Provisions) Act 1968).

Codes of recommendations for the welfare of livestock were introduced the following year and have since been regularly updated.

In 1979 the FAWAC was replaced by the Farm Animal Welfare Council (FAWC), an independent advisory body made up from a panel of experts from various fields. The remit of the council was to continuously review the welfare of farm animals on agricultural land, at markets, in transit and at the place of slaughter, and to advise the Agricultural Ministers of any legislative or other changes which may be necessary (Farm Animal Welfare Council, 1988).

In a recent consumer survey carried out by Reading University 80 per cent of people surveyed expressed concern at the way livestock was produced. About half said they avoided purchasing certain products about which they had welfare concerns, while 21 per cent bought certain other products since they believed they were from systems with better welfare (Anon., 1996a). Another study indicated that 80 per cent of the public were prepared to pay more for 'welfare friendly food' but that there was a dramatic reduction once the selling price reached 25 per cent above that of the standard product (Anon., 1996b). On the basis of this data, and on their own report, the Royal Society for the Prevention of Cruelty to Animals (RSPCA) has commissioned research and provided investment in the 'Freedom Food' initiative which is an assurance scheme identifying meat products from husbandry systems with high standards of welfare based on the 'Five Freedoms' (Mews, 1992). More than 2000 stores now stock Freedom Food products including Tesco, Safeway, Somerfield, the Co-op and Asda. More than 1200 farmers, hauliers and abattoirs have Freedom Food accreditation (Anon., 1997a).

Since the establishment of the Freedom Foods scheme other assurance schemes stemmed from the pig industry. Farm Assured British Pigs (FABPigs) was the UK pig industry's own independent quality assurance scheme and accounted for over 60 per cent of British production (Anon., 1997b). One of the major aims of this scheme was to address consumer concerns over animal welfare (Anon., 1996b). The UK's leading pig meat processor Malton foods launched its own quality assurance scheme incorporating a welfare code based on the 'Five Freedoms' (Anon., 1997c). The scheme was subject to on-going improvements identified in a programme of investment in research and development. The company stated that tail biting, environmental enrichment and farrowing crates were primary areas of concern.

### *1.1.2 Definitions of animal welfare*

Animal welfare is a subject of great complexity and complications. This is, in part, due to the numerous definitions employed by different research scientists to define it. The Oxford English Dictionary (1973 edition) defines welfare as 'well-being, happiness', while the Chambers Dictionary (1983 edition) offers 'a state of faring well'. Welfare has been described solely in terms of biological fitness, i.e. welfare is only reduced if the animal's ability to survive and reproduce is diminished (Barnett and Hemsworth, 1990). Others have stated that an animal's welfare is only compromised when it is experiencing an unpleasant mental state (Dawkins, 1980; Duncan and Petherick, 1989).

Sainsbury (1986) refrains from attempting to define welfare in his book 'Farm Animal Welfare' but suggests that animal health should be the most important factor. Barnard and Hurst (1996) suggest that the criteria for the welfare of an animal is how close its current experiences are to what it was genetically programmed to do. Broom (1986) defined the welfare of an individual as 'its state with regard to its attempts to cope with its environment'. This implies that an animals' welfare is dictated by its ability to adapt to different stimuli i.e. welfare is threatened when an animal fails to cope.

Fraser and Broom (1990) suggest that welfare exists as a continuum from poor to good welfare and this philosophy seems to be adopted by most scientists. Webster (1995) defines welfare not only in terms of an animal's current state within this continuum but also in terms of its ability to sustain physical and mental fitness and so preserve not only its future quality of life but also the survival of its genes. His definition states that 'the welfare of an animal is determined by its capacity to avoid suffering and sustain fitness.

The Brambell committee suggested that 'Welfare is a wide term that embraces both the physical and the mental wellbeing of the animal. Any attempt to evaluate welfare, therefore, must take into account the scientific evidence available concerning the feelings of animals that can be derived from their structure and function and also from their behaviour' (Brambell Committee, 1965).

A number of scientists combine the physical and mental attributes of animals into single definitions. Hughes (1976a) states that 'welfare on a general level is a state of complete

mental and physical health where the animal is in harmony with its environment'. Wood-Gush (1983) and English *et al.* (1988) give similar definitions.

A number of the above definitions have included the term suffering and several authors have attempted to define the word independently. The Brambell Report (Brambell Committee, 1965) listed fear, pain, frustration and exhaustion as examples of suffering. Duncan and Dawkins (1983) suggest that this method of drawing up a list of states has the disadvantage that some may be missed. They suggest a loose working definition of suffering as '...a wide range of unpleasant emotional states'. Dawkins (1990) later gives a more precise definition; 'suffering occurs when unpleasant subjective feelings are acute or continue for a long time because the animal is unable to carry out the actions that would normally reduce risks to life and reproduction in those circumstances'.

### *1.1.3 Stress and animal welfare*

The concept of stress, whether it be emotional, physical, physiological or another form is important to the understanding of animal welfare. However, like the term animal welfare, various authors have used the word 'stress' in different and, sometimes, inconsistent ways leading to confusion (Dawkins, 1980). In fact it has been suggested that the term stress should be avoided (Rushen, 1986).

Hans Selye proposed a set of standardised definitions referring to his work concerning biological adaptation to adverse environments (Broom and Johnson, 1993). He proposed that stress was the biological consequence of exposure to an adverse environment (Selye, 1973). The term 'stressors' was used to describe the adverse conditions and the resulting attempts to cope with the stressors as stress 'responses'; this being the concept defining Broom's definition of welfare (Broom, 1986 - section 1.2). Selye (1946) suggested the existence of a General Adaptation Syndrome (GAS) as a general response to a stressor. It was proposed that this syndrome was composed of three distinct phases - an initial alarm reaction, a second stage of resistance to the stressor and a final stage of biological exhaustion, and eventually, death. This concept was developed by Stephens (1980) who suggested that there was an essential similarity between biological response to different stressors. According to Stephens, an aversive stimulus or acute stressor would cause an increase in the activity of the sympathetic nervous system resulting in various physiological changes such as the release of catecholamines adrenaline and noradrenaline from the adrenal medulla and an increase in heart rate. If the stressor persisted it would eventually activate the hypothalamic-pituitary axis resulting in the release of corticosteroids from the adrenal cortex -termed chronic stress.

Fraser *et al.* (1975) stated that an animal is in a state of stress if it is required to make abnormal or extreme adjustments in its physiology or behaviour in order to cope with adverse aspects of its environment and management.

#### *1.1.4 Measuring animal welfare (general information)*

There is a wide range of techniques reported in the literature to evaluate animal welfare, but no single indicator of animal welfare has yet been identified and universally accepted (Broom, 1997). The methods used tend to reflect which definition of animal welfare a particular scientist prefers. Those that believe that the subjective experiences of an animal are what determines its welfare (Dawkins, 1980; Baxter, 1983; Duncan and Dawkins, 1983; Fraser, 1995; Weary and Fraser, 1995) will look for indicators of an animal's 'feelings' as subjective states which cannot be investigated directly (Duncan and Dawkins, 1983). Such indicators include determining an animal's preference for one stimulus over another and measuring its motivation to perform a certain behaviour pattern (e.g. Dawkins, 1983a; Hughes, 1976b). However Dawkins (1980) has also stated that animals may not always choose in the best interest of their welfare. Use of this terminology implies that welfare only exists as a concept for those animals that are capable of experiencing subjective feelings.

Other scientists who equate biological fitness with welfare will measure productive parameters such as growth rate, reproductive performance, health, etc. (e.g. Barnett and Hemsworth, 1990). A third group of scientists will work on the assumption that the natural existence of an animal is what is best for its welfare (Barnard and Hurst, 1996; Kiley-Worthington, 1989; Rollin, 1993) this being the underlying theory of the fifth Freedom proposed by Farm Animal Welfare Council (1993 - 'freedom to display most normal (or natural) patterns of behaviour'). An example of work in this area is that of De Jonge (1996) who found that rearing pigs in barren conditions until weaning resulted



in increased aggression due to a lack of proper social development and social stress in subordinate pigs. Stolba and Wood-Gush (1989) investigated the behaviour of domestic pigs under semi-natural conditions in order to identify behavioural key features and incorporate them into a housing design for pigs.

Most scientists including those listed above will acknowledge that a range of indicators must be measured in order to evaluate an animal's welfare. Dawkins (1983b) states that 'different measures of welfare do not correlate. It is dangerous to put much weight on any one'. Fraser (1989) suggests that 'animal welfare is a compound discipline with relevance to veterinary medicine, animal research, animal husbandry and applied animal ethology and as such is essentially multi-disciplinary'.

For evaluation purposes indicators of poor and good welfare have been defined (see sections 1.3 and 1.4). The 'Codes of Recommendations for the Welfare of Livestock' (Ministry of Agriculture, Fisheries and Food, 1983) state that to maintain good welfare an animal should be provided with:

- i. comfort and shelter;
- ii. readily accessible fresh water and a diet to maintain the animals in full health and vigour;
- iii. freedom of movement;
- iv. the company of other animals, particularly of like kind;

- v. the opportunity to exercise most normal patterns of behaviour;
- vi. light during the hours of daylight, and readily available lighting to enable the animals to be inspected at any time;
- vii. flooring which neither harms the animals, or causes undue strain;
- viii. the prevention, or rapid diagnosis and treatment, of vice, injury, parasitic infestation and disease;
- ix. the avoidance of unnecessary mutilation;
- x. emergency arrangements to cover outbreaks of fire, the breakdown of essential mechanical services and the disruption of supplies.

#### *1.1.5 Problems in assessing welfare*

The difficulties involved in the assessment of animal welfare are reviewed by Mason and Mendl (1993). They also suggest that the exact way in which scientists define welfare will clearly influence the types of measure they use to attempt to assess welfare objectively. A major problem is the lack of specificity between an aversive stimulus and a response. This response can be affected by many factors including the type of stimulus, the animal's psychological state, the timing and duration of the stimulus, species differences and individual differences. All of these may have an effect on the results of experiments investigating animal welfare. Since knowledge concerning many of these factors, how they interact and how they affect the animal, is limited, care must be taken in the interpretation of results. Another problem is the similarity in the

response to stressful stimuli and other normal physiological effects. The concentration of corticosteroid in the blood, the hormone primarily associated with stress and often used as an indicator of welfare, can be also be increased during sexual activity, mild exercise and in the anticipation of food (Rushen, 1986).

Barnett and Hemsworth (1990) review the validity of physiological and behavioural measures of welfare and conclude that the physiological approach to welfare assessment is further advanced than that of behavioural assessment with specific reference to abnormal behaviour due to ignorance of how to interpret such measures. Rushen (1991) agrees with Barnett and Hemsworth in their claims of problematic interpretation of behavioural indicators of welfare but suggests that they under-emphasize the difficulties in interpreting physiological data, particularly that concerning the activity of the pituitary-adrenocortical axis. Rushen's review presents a number of anomalies in physiological assessment of welfare in order to support this view.

Duncan and Fraser (1997) conclude that science cannot provide a purely objective assessment because the conclusions we draw about an animal's welfare are based on value judgements as well as knowledge.

## 1.2 Pig behaviour

### 1.2.1 Behavioural needs

The fifth freedom as defined by the Farm Animal Welfare Council is the freedom to express normal behaviour. This implies that restriction of normal behavioural patterns leads to frustration and therefore reduces the welfare state of an animal.

The reasoning behind this recommendation is derived from the observation of behaviour of animals under artificial conditions; for example it has been observed that a sow will exhibit nest-building behaviour despite being provided with a serviceable nest, seeming to expend energy on a meaningless task (Arey *et al.*, 1991). Similar behaviour has also been observed in hens (Hughes *et al.*, 1989). The barren environment of modern intensive husbandry systems has been criticised due to the behavioural restriction or deprivation imposed on animals (Dawkins, 1988) and it is apparent that to avoid suffering more is needed than the basic requirements of temperature, food and water.

Dawkins (1983) differentiates between such behavioural or ethological needs and the ultimate needs of an animal. Ultimate needs are those that are considered essential, such as food and water and if not met will result in reproductive failure and death of the animal. Behavioural needs are not considered to be essential in that deprivation may not physically harm the animal but may still cause suffering.

### *1.2.2 Theories of motivation*

To explain why animals performed certain behaviours, early behavioural scientists suggested that they were simply genetically programmed to perform particular responses to environmental stimuli. This view has since been discredited has since been replaced by a series of theories describing the mechanisms underlying animal behaviour, central to these theories is the concept of motivation.

#### *1.2.2.1 Drive theory and the psychohydraulic model*

Initial theories of motivation were based on very simple descriptive models - i.e. a stimulus will provoke a response, which will then act as a releaser for a subsequent action. Tinbergen (1951) proposed such a model when analysing the courtship behaviour of sticklebacks. They demonstrated how each partner's response in turn acted as a releaser for the next stage in the behavioural sequence. The concept of drive theory was introduced by Woodworth (1918). This was accepted as the general view of motivation which was purported to be based on a simple feedback mechanism. The brain senses a change in the animal's internal state that causes an increase in the drive to perform a particular behaviour. The initial behaviour is described as being appetitive. This is followed by consummatory behaviour, which reduces the internal drive by reducing the causative internal stimulus and eventually results in its cessation. This theory was developed by Lorenz (1950) into the psychohydraulic model - an abstract model using the accumulation and flow of liquid to demonstrate its principles. Lorenz's model stated that an accumulation of action specific energy will give rise to appetitive

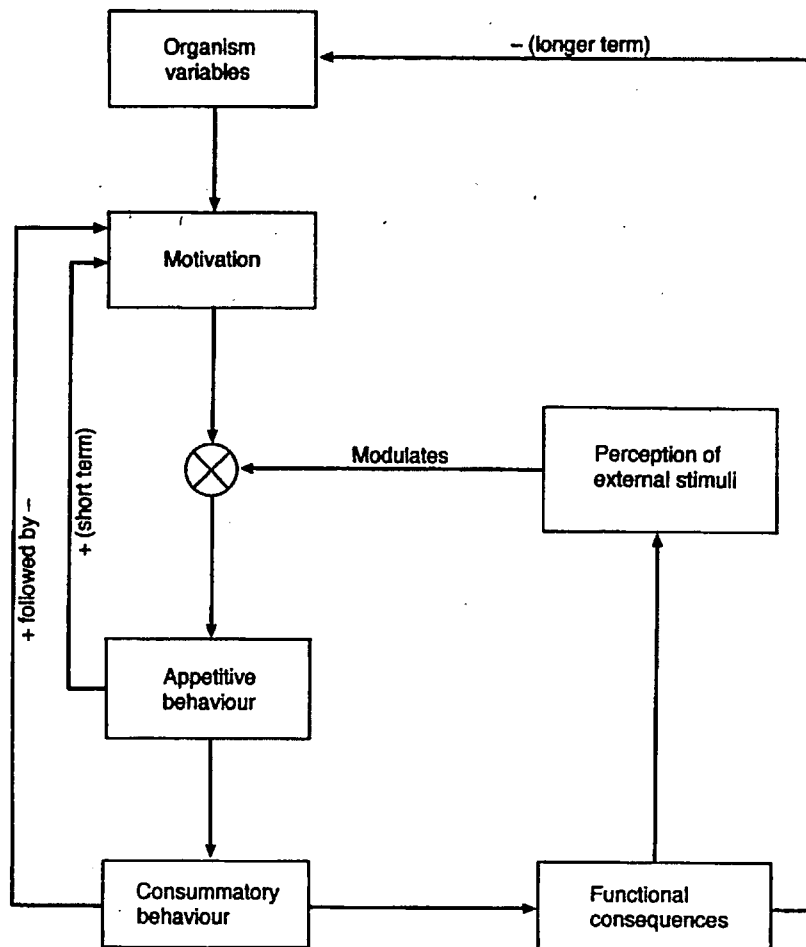
behaviour. The performance of the appetitive behaviour and the attaining of the stimulus for a particular behaviour pattern will activate an innate releasing mechanism. The activation of this releasing mechanism will then result in the discharge of the action specific energy in the form of consummatory action.

#### 1.2.2.2 Homeostatic models

Deutsch (1960) proposed a model based on homeostatic mechanisms. A deficit in the internal medium e.g., low blood glucose, is detected by the central structure or link (located somewhere in the nervous system). This activates a motor system causing the environment to vary e.g. commencement of feeding resulting in stomach fill. This change in the environment is detected by the analyser and switches off the link causing an end to the behaviour. The link is now unresponsive to the internal medium, an inhibition that reduces with time until the link is once again sensitive to excitation.

Baxter (1983) proposed a variant to Deutsch's model. The emphasis is put on behaviour altering the animal's environment (functional consequences) which leads to termination of the behaviour through the perception of external stimuli and also by direct inhibition of motivation. The fundamental difference between this and Deutsch's model is that the negative feedback acts directly on the level of motivation rather than indirectly through alterations of organism variables.

Baxter proposed that the concept of behavioural needs was misguided. According to his model, if the environmental and physiological needs of animals were carefully monitored and adjusted there would be no need for an animal to perform behaviour in order to maintain its welfare. Hughes and Duncan (1988) discussed Baxter's model and cite the nest building requirements of domestic fowl (discussed in section 1.2.1 - Hughes *et al.*, 1989) as reasons for the model's limitations. They propose a modification of this model (figure 1.1) that suggests that the performance of the behaviour may be inherently important. There are three significant alterations; 1. the separation of behaviour into appetitive and consummatory behaviour; 2. the performance of behaviour directly feeds back on motivation; and 3. the functional consequences no longer directly affect motivation but now affect it indirectly through organism variables.



**Figure 1.1 The Hughes and Duncan model of animal behaviour (Hughes and Duncan, 1988 – diagram from Petherick and Rushen, 1997).**

### 1.2.2.3 The Regulatory Model

Wiepkema (1983) describes an alternative model similar to the homeostatic model. The animal is in continuous interaction with its dynamic ‘Umwelt’ - the current state of an animal. The animal attempts to match its current internal and external state ‘Istwert’, to a specific goal state ‘Solwert’. The larger the difference between the Solwert and the Istwert the greater the motivation, but large differences can have negative effects.



#### 1.2.2.4 Consumer Demand Theory

Duncan and Dawkins (1983) proposed that the term 'behavioural needs' should be replaced with 'tendencies to behave in particular ways' and it should be possible to use a variety of experimental techniques to measure the strength of these tendencies. Dawkins (1983) applied consumer demand theory in researching this area and replaced the term 'needs' with the economic definition of 'necessities'. Items that were considered 'necessities' continue to be bought when income is restricted, whilst consumption of 'luxuries' was reduced. Behaviours described as necessities tended to appear even when constraints on behaviour were imposed, but luxury behaviours tend to appear only when there are no such constraints. 'Necessity' behaviours were described as having 'inelastic' properties, whilst 'luxury' behaviours were said to show 'elastic' properties.

#### *1.2.3 General information concerning pig behaviour*

As mentioned above (section 1.1.4) the behaviour of pigs under natural conditions has been suggested to indicate optimum welfare conditions. Stolba and Wood-Gush (1989) found that domestic pigs kept under semi-natural conditions followed an ethogram very similar to that of their wild boar ancestors. This ethogram was very complex and consisted of 103 different behavioural elements. Dawkins (1988) stated that the range of behaviour performed by animals in captivity is usually reduced when compared to their wild counterparts. Numerous studies investigating the behaviour of pigs under intensive husbandry conditions (e.g. Warnier and Zayan, 1985; Schouten, 1986; Newberry *et al.*,

1988; Pearce *et al.*, 1989; Wood-Gush and Vestergaard, 1989; De Jonge, 1996) have suggested that the welfare of these pigs is reduced due to behavioural restriction.

#### *1.2.4 Non-social behaviours*

##### *1.2.4.1 Feeding and drinking behaviour*

Wild and feral pigs spend over 25% of their time performing feeding related behaviour (Mauget, 1981). Pigs kept in modern production systems are usually fed upon energy-dense compounded foodstuffs which are readily available compared with the time-consuming rooting behaviour of pigs in the wild. The domestic pig may consume its daily food requirement in as little as 15 minutes (Fraser and Broom, 1990). Another study has shown that the confined growing/finishing pigs given *ad libitum* access to food spend approximately 2-2.5 hours feeding (Gonyou *et al.*, 1992). This study found that there was no difference in the time spent feeding between individually -housed pigs or pigs housed in groups of five, although the individually housed pigs had higher actual food intakes, resulting in increased weight gain. Aggression at the feeder may be responsible for this difference (Baxter, 1983). Gonyou *et al.* (1992) also found that feeding behaviour followed a diurnal pattern with peaks at 8am and 4pm.

Pigs given *ad libitum* access to food and water will randomly space their eating and drinking periods throughout the day (Fraser and Broom, 1990). Feeding behaviour is socially facilitated in that the sight of other pigs feeding will stimulate it (Hsia and Wood-Gush, 1984).

Restriction of feeding behaviour (particularly the foraging aspect) in pigs through providing readily available feed without the need for extensive foraging has been associated with a number of abnormal behaviours including bar-biting, head-weaving, vacuum chewing, tail-biting and polydipsia (Rushen, 1985; Appleby and Lawrence 1987; Yang *et al.*, 1981; Wood-Gush and Vestergaard, 1989) have been suggested to occur due to boredom (Newberry *et al.*, 1988; Wood-Gush and Vestergaard, 1989) or nutritional deficiencies (Rushen, 1993).

#### 1.2.4.2 Excretory behaviour

Pigs tend to excrete away from their feeding and lying areas (Baxter, 1982) preferring to defecate beside walls, particularly in corners. Baxter (1982) suggested that this may be due to some requirement for protection due to the unbalanced position during defecation rendering the pig vulnerable to attack.

An investigation into the influence of climatic variables on excreting patterns reported that the positions for lying and excreting within a pen could be reversed by modifying the airflow pattern so that the initial lying area became cooler than the excretory area (Randall *et al.*, 1983).

#### 1.2.4.3 Exploratory behaviour

Pigs kept in a semi-natural environment spend the majority of their time performing exploratory and foraging behaviours (Stolba and Wood-Gush, 1989). This behaviour is usually performed by rooting using the nose followed by manipulation using the mouth (Hughes and Duncan, 1988). The barren environment of the modern intensive husbandry system provides little stimulation for exploration which has been suggested to result in deprivation of this behavioural pattern (e.g. Wood-Gush, 1983).

Wood-Gush *et al.* (1990) reported that the motivation of piglets to explore a novel environment or a novel object in the home pen was increased in pigs reared under barren conditions compared with those reared under enriched conditions. Results of a subsequent experiment showed that piglets would select an environment containing a novel object over one containing a familiar one (Wood-Gush and Vestergaard, 1991) which was suggested to indicate the presence of an underlying motivational system with endogenous activating mechanisms as opposed to the behaviour being simply inspective curiosity in reaction to the stimulus. It was then further suggested that rearing under barren conditions may result in redirected exploratory behaviour towards other stimuli such as the ears and tails of pen mates.

The performance of exploratory behaviour has been reported to be influenced by a number of other factors besides complexity of the environment. Jensen *et al.* (1995a) reported that pigs subjected to one week of intermittent stress (procedure associated

with the initiation of blood collection) increased their exploratory behaviour in an open-field test (increased centre location) but after 4-5 weeks showed less exploratory behaviour relative to a control group. Pearce and Paterson (1993) suggested that exploratory behaviour was reduced in crowded pigs compared to uncrowded pigs (space allocation according to the equation  $A = kW^{0.66}$  (where  $A$  = individual space allowance,  $W$  = mean group body weight and using values for constant  $k$  of 0.048 for uncrowded treatments and 0.025 for crowded). In the crowded treatments the provision of toys increased exploratory behaviour compared with a barren environment.

#### 1.2.4.4 Locomotory behaviour

Fraser and Broom (1990) state that while piglets are nimble and capable of running, the mature domestic pig, with its relatively massive trunk, is ill-equipped for movement at speed. Pigs kept under semi-natural conditions spend approximately 14% of their daylight hours performing locomotory behaviour (Stolba and Wood-Gush, 1989). Wild and feral pigs spend 16.5% of their time in locomotion (Mauget, 1981).

#### 1.2.4.5 Resting behaviour and activity level

Of all farm animals pigs spend most time resting and sleeping, usually in groups, for as much as 19 hours each day (Fraser and Broom, 1990). Studies of wild and feral pigs have reported that they spend 58.3% of their time resting (Mauget, 1981) while pigs in a semi-natural enclosure spend 60% of their time lying down.

Resting behaviour is influenced by various factors. Fraser (1995) reported that sows spent more time lying when straw was provided while another study (Fraser *et al.*, 1991) showed that there was no difference between activity levels of young growing pigs with and without straw. However a number of studies have found increases in the active behaviour pigs given straw relative to those without (Broom, 1991; McKinnon *et al.*, 1989; Schouten, 1986; Pearce, 1993). Pigs stressed by unpleasant handling perform significantly more resting behaviour than pigs subjected to minimal or pleasant handling (Pearce *et al.*, 1989).

### *1.2.5 Social behaviours*

#### *1.2.5.1 Formation and maintenance of social structure*

A study investigating the social structure of pigs reported that out of 706 observed aggressive acts, all but two followed a consistent linear order (Rasmussen *et al.*, 1962). The highest-ranking animal attacked all other animal but was never the subject of aggression, the second ranking animal attacked all other animals except the 'alpha' animal, etc. Baxter (1985) states that although the concept of a linear social structure has never been disputed in principle for pigs, it has usually been found to be less unidirectional and less linear than found in the study by Rasmussen *et al.* (1962). This linear social structure has been shown to be fairly rigid in its form. An investigation into dominance testing involving pairs of pigs competing for food showed that 70% of these test pairs maintained their relative social ranking over three tests separated by 7 day intervals (Baxter, 1983). Another study reported that high-ranking pigs removed from

the social group would retain their status on re-introduction after an absence of up to 25 days (Ewbank and Meese, 1971).

This idea of a 'dominance order' has subsequently been replaced with the concept of an 'avoidance' order (Jensen, 1984). This has been suggested due to the fact that the order appears to be maintained primarily through the social behaviour of the subordinate animals towards those of higher rank rather than aggressive acts of the dominant animals.

Fraser and Broom (1990) state that avoidance serves to reduce contests between individual animals, implying that this form of social stabilisation is adaptive. It is accepted that the social structure is established in order to reduce fighting whilst competing for resources such as food, water and resting sites (Baxter, 1985). Pigs kept under semi-natural conditions spent 4% of the daylight hours performing agonistic behaviour (Stolba and Wood-Gush, 1989).

#### 1.2.5.2 Individual recognition

Recognition of other individual pigs is initially based on sight and smell (Ewbank *et al.*, 1974; Meese and Baldwin, 1975) with sight becoming relatively unimportant following the establishment of the social hierarchy.

### 1.2.5.3 Communication using vocalisations

Pigs possess a repertoire of different vocalisations, varying in pitch and frequency (Xin *et al.*, 1989). There is little information as to their function (Kiley, 1972), but it is known that the sow emits lactation grunts to communicate information about suckling periods to piglets (Blackshaw *et al.*, 1996), piglets perform vocalisations directed at the sow (Weary and Fraser, 1995) and pigs grunt during exploratory behaviour and may squeal when under stress (Fraser, 1974; Xin *et al.*, 1989).

### 1.2.5.4 Communication using pheromones

Olfactory stimuli are important in the social communication of pigs. Boars produce pheromones in urine and foam emissions from the mouth to accompany sexual behaviour in order to elicit receptive behaviour and increased fertility in the sow (Melrose *et al.*, 1971; Hemsworth *et al.*, 1978; Pearce and Hughes, 1987a, 1987b; Soede, 1993).

Pheromones also play an important role in aggression by eliciting submissive behaviour in fighting pigs (McGlone, 1985) and can also increase aggression (McGlone *et al.*, 1987). A pheromone has been reported to exist in the urine of gilts that have undergone an alarming situation (restraint) that is aversive to other gilts (Vieuille-Thomas and Signoret, 1992)



## 1.3 Physiological assessment of pig welfare

### *1.3.1 Response to acute stress*

The body has adapted a variety of mechanisms to respond to alterations, or stressors, in their environment. Physiological mechanisms include:

#### 1.3.1.1 Heart rate

Increases in heart rate (tachycardia) occur when the level of physical activity of an animal increases, but it can increase or decrease in response to emotional stressors (Broom and Johnson, 1993). A study of pigs reported that their basal heart rate of 138 beats per minute was increased to 207 beats per minute when the animals were made to climb a ramp (Putten and Elshof, 1978).

Potential stressors have also been shown to cause variation in the heart rate of other farmed species, e.g. handling in sheep (Syme and Elphick, 1982; Baldock and Sibly, 1990) and cows (Stephens and Toner, 1975), responses to humans by hens (Duncan and Filshie, 1979) and transport of hens (Nicol and Scott, 1990) and sheep (Baldock and Sibly, 1990). Baldock and Sibly (1990) reported that recording basal levels of sheep engaged in normal activities allowed them to separate the effects of heart rate of an emotional stressor from those attributed to an increase in physical activity.

### 1.3.1.2 The adrenal axes

Broom and Johnson (1993) state that measurements of activity in the sympathetic-adrenal medullary system and in the hypothalamic-pituitary-adrenal (HPA) cortex system are important in assessing how animals cope with acute stressors. Cannon (1929) recognised the existence of a consistent response to acute stress by the sympathetic nervous system and termed it the “flight-fright response.

Sympathetic activation of the adrenal medulla results in the production of the catecholamines adrenaline and noradrenaline. However these are rarely used in welfare assessment of pigs (Broom and Johnson, 1993).

Much more common are measurements made from the HPA-axis, the mechanisms of which are described by Axelrod (1984). The first stage of activity is the secretion of corticotrophin releasing factor (CRF - also known as corticotrophin releasing hormone or CRH) following stimulation of the hypothalamus. This results in the release of adrenocorticotrophic hormone (ACTH) from the anterior pituitary. ACTH is carried in the blood to the adrenal cortex where it stimulates the release of the glucocorticoids cortisol and corticosterone. These glucocorticoids suppress further production of CRF and ACTH and so measurements of these hormones must be within a few minutes of the initial stimulus and is usually considered impractical.

CRF, ACTH and corticosteroids are released according to a diurnal rhythm with secretory episodes that are unevenly distributed over the 24-hour period (Terlouw *et al.*, 1997). Within this sinusoidal waveform are a number of other peaks (termed ultradian variation) (Ixart *et al.*, 1987). It has been reported that in female growing pigs, plasma cortisol concentration peaked between 05.00 and 10.00 hours and reached a minimum between 17.00 and 22.00 hours (Malmhof, 1988). It has been suggested that cortisol sampling should take place in the afternoon as individual variation is minimal during this period (Barnett, Hemsworth and Hand, 1983).

Care must be taken in the measurement of glucocorticoids as collection techniques will induce a stress response (Broom and Johnson, 1993). Ekesbo (1981) suggested that physiological assessment of welfare is limited due to such technical difficulties. Plasma cortisol concentration is the usual method of assessing acute stress using the activity of the HPA-axis. Broom (1986) suggested that alternative, non-invasive techniques should be investigated in order to assess the welfare of animals through physiological indicators. Cortisol in the saliva of pigs can be measured using an enzyme-linked immunosorbent assay (ELISA) (Cooper *et al.*, 1989) and is present at a concentration of 10% of that found in plasma (Parrott *et al.*, 1990). Parrott *et al.*, (1990) suggested that pig salivary cortisol is a useful indicator of welfare.

### 1.3.1.3 Neurotransmitters

Responses to novel, threatening and alarming environmental events involve the dopaminergic and noradrenergic system in the brain (Broom and Johnson, 1993). It has been demonstrated that confined sows are less responsive than their free-living counterparts and it has been suggested that this is a coping mechanism (Broom, 1987). Broom (1987) proposed that this effect was due to some neural gating process that may reduce sensory input or arousal and this process may be mediated by the action of analgesic peptides. This suggestion is supported by other findings that stereotypic behaviour in tethered sows is associated with the release of endorphins (analgesic peptides) in the brain (Cronin, 1985).

### 1.3.2 *Response to chronic stress*

#### 1.3.2.1 Hypothalamic-pituitary-adrenal axis

Sustained elevated levels of free corticosteroid concentrations have been suggested to be indicative of poor welfare in pigs (Barnett and Hutson, 1987). This is because of a reduction in the fitness of the pig due to an associated increased gluconeogenesis and reduction of protein incorporation into tissues (Barnett *et al.*, 1983).

Continual activation of the adrenal cortex in response to stressors can result in hypertrophy of the adrenal gland (Broom, 1986). It has been suggested that measurement of basal cortisol concentrations in order to determine stress levels and

welfare is of limited use (Rushen, 1991 - see 1.5). An improved method of assessing environmental effects on adrenal activity is the use of an injection of adrenocorticotrophic hormone (ACTH), termed an ACTH challenge (Pearce and Paterson, 1993). It is based on work in rats, which demonstrates that exposure to chronic stress alters the response of the adrenal gland to subsequent acute stressors (Sakellaris and Vernikos-Danellis, 1975). It has since been successfully used to demonstrate chronic stress in pigs (e.g. Borell and Ladewig, 1989; Meunier-Salaun *et al.*, 1987, Pearce and Paterson, 1993).

Pigs reared in a barren environment have lower basal cortisol levels than those reared in more enriched conditions and have a blunted cortisol circadian pattern compared to normal (De Jong *et al.*, 1998; De Groot *et al.*, 2000). Factors found to induce a cortisol response include tethering of sows (Janssens *et al.*, 1994), acute restraint (Janssens *et al.*, 1995), isolation and restraint (De Jong *et al.*, 1998), mixing (Ekkel *et al.*, 1997), transport (Parrott *et al.*, 1990) and social defeat (Ruis *et al.*, 2001). Rearing in a barren environment increases the cortisol response to restraint compared to rearing in a more complex environment (De Jonge *et al.*, 1996). Space restriction has been shown to increase cortisol response to an ACTH challenge (Meunier-Salaun *et al.*, 1987; Pearce and Paterson, 1993).

## 1.3.2.2 Immune Function

The pig's immune response may be influenced by exposure to stressors (Johnson *et al.*, 1994; Wallgren *et al.*, 1994b). Animals which utilise their adrenal cortex frequently may have an impaired immune function and an increase susceptibility to disease (Kelley, 1980). Sows which showed a large cortisol response to challenge with ACTH also showed suppressed antibody production after challenge with a tetanus toxoid antigen (Zanella *et al.*, 1991). Zanella *et al.*, (1991) stated that measures of immune function were important indicators of welfare. Broom (1996) lists a series of measures to determine immunosuppression: simple measures of white cell numbers, measures of antibody response to antigen challenge and measures of T-lymphocyte function.

Various factors have been found to affect immune status. Components of the physical environment that have been found to alter immune function are heat and cold stress (Machado-Neto *et al.*, 1987; Morrow-Tesch *et al.*, 1994), cold (Blecha and Kelley, 1981), intermittent draughts (Scheepens *et al.*, 1991b) and a chronic space restriction (Turner *et al.*, 2000). Social regrouping has also been found to be important (Moore *et al.*, 1994) as well as the combined stressors present at weaning (Blecha *et al.*, 1983; Blecha *et al.*, 1985; Bailey *et al.*, 1992; Wattrang *et al.*, 1998). Management factors found to be important include the use of tethers for pregnant sows (McGlone *et al.*, 1994) and transport (Dahlin *et al.*, 1993, McGlone *et al.*, 1993).

### 1.3.2.3 Growth rate

A reduced growth rate is a possible indicator that a pig is unable to cope with its present environment and is therefore suffering from a reduction in welfare (Broom, 1986). It has been suggested that chronic elevation of cortisol may reduce growth rate in pigs by enhancing gluconeogenesis and reducing protein incorporation into tissues (Barnett *et al.*, 1983). Pearce *et al.* (1989) reported that reduced growth rates were associated with adrenal hypertrophy in pigs and that chronic stress may affect pig productivity.

### 1.3.3 Signs of injury and disease

#### 1.3.3.1 Skin lesions

A Swedish veterinarian, Prof. Dr. I. Ekesbo suggested that the state of the integument of an animal might be a good indicator of the wellbeing (welfare) of that animal (De Koning, 1984). De Koning (1984) investigated the welfare of sows in different housing systems using a scoring system based on the skin lesion patterns of a number of animals from each system. 52 sites on the integument were inspected and scored according to the following scale: de-hairing and callosities were given 1 point; moderate swellings and scars 2 points; severe swellings and moderate wounds 3 points; severe wounds 5 points. This system was successfully used to differentiate the welfare state of sows kept under different husbandry systems. The Ekesbo method has subsequently been used to assess the welfare of piglets using an adapted scale (Veen *et al.*, 1985). A score from 0-3 points was given to the following areas of the piglet: the ears, snout, teats, navel, tail,

preputium or vulva, claws of fore and hind legs. These scores were then totalled to give a single overall body score.

Skin lesions can be caused by sharp or abrasive pen fixtures and fittings (Sainsbury, 1982) but are often as a result of aggressive behaviour, particular at grouping of unfamiliar pigs where injuries are mainly concentrated around the head and shoulders (Veen *et al.*, 1985).

#### 1.3.3.2 Leg Problems

Fraser and Broom (1990) stated that non-infectious disease such as those leading to foot and leg problems are related to environmental conditions and the animal's attempts to cope with them. Therefore such problems are indicative of reduced welfare. Recommendations for the welfare of pigs state that animals should be kept "on flooring which neither harms the animal nor causes undue strain" (MAFF, 1991). Bursitis is a condition of the legs caused by traumatised capillaries and lymphatic vessels forming bursae - fluid-filled sacs - as a result of pressure on the skin over a bony prominence (Mouttotou *et al.*, 1998a). Mouttotou *et al.* (1998b) suggested a scoring system for assessing bursitis: score 0 indicated a normal limb (no lesions), score 1 indicated a small bursa (the size of a hazelnut), score 2 indicated a larger well-shaped bursa (the size of a walnut) and score 3 indicated a bursa the size of a hen's egg. This scoring system was successfully used to differentiate the effects of various floor types on the prevalence of bursitis.



A study of finishing pigs on commercial units found that pigs kept on solid floors with deep straw (>10 cm) had the lowest risk of having bursitis, prevalence increasing successively when the floors were solid concrete with sparse straw (<10 cm), partially-slatted and fully slatted (Moultotou *et al.*, 1998a). The importance of straw bedding in the prevention of bursitis has also been demonstrated in other studies (Smith and Smith, 1980; Pearce, 1993).

Increasing age, increased time spent in the pen, a wet slurry film in the dunging area and a difference in height of greater than 3 cm between the lying and dunging areas have also been found to be associated with increased bursitis prevalence (Moultotou *et al.*, 1999) as well as increased stocking density (Moultotou *et al.*, 1998a).

#### 1.3.3.3 Gastric Ulcers

Exposure to environmental stressors may cause gastric ulceration in pigs (Kowalczyk, 1969; O'Brien, 1992; Kavanagh, 1994). It occurs in pigs of all ages although it is most common in pigs over six weeks old (Kavanagh, 1994).

Kavanagh (1994) proposed a scoring system for classifying ulcers by their severity ranging from the normal stomach through parakeratosis (epithelial layers become corrugated, elevated, irregular and roughened), and erosions (broken epithelium results

in active ulceration and haemorrhage), to chronic ulcers (a fibrous tissue reaction in previously ulcerated areas).

Dybkjaer *et al.*, (1994) found that there were associations between some behavioural indicators of stress (redirected oral behaviour patterns) and the occurrence of stomach lesions in 95 kg slaughter pigs.

There are many risk factors associated with gastric ulceration, most commonly associated with intensified husbandry (Kowalczyk, 1969; Zamora *et al.*, 1980). However, the main risk factors associated with gastric ulceration are those concerned with the diet (Potkins *et al.* 1989a; Wondra *et al.*, 1995b; Henry, 1996). Interruption in the diet or fasting may be the primary factor in inducing gastric ulcers in pigs (Chamberlain *et al.*, 1967; Pocock *et al.*, 1968; Davies *et al.*, 1994; Straw *et al.*, 1994; Lawrence *et al.*, 1998) but causes may vary from disease (Dybkjaer *et al.*, 1998) to general environmental stressors (Wondra *et al.*, 1995b). Other important dietary risk factors include small particle size (Potkins *et al.*, 1989a; Healy *et al.*, 1994; Wondra *et al.*, 1995a, 1995b, 1995c) and pelleted diets (e.g., Potkins *et al.*, 1989a; Wondra *et al.*, 1995b). Crude fibre has also been reported to have a protective effect on the development of gastric lesions (Potkins *et al.*, 1989a). It has been suggested that the additional dietary fibre may break up the more fluid digesta from fine diets, preventing the erosion of the pars oesophageal region (Potkins *et al.*, 1989a). Environmental stressors that have been associated with gastric ulceration include large group size

(Backstrom *et al.*, 1988), transport (Lawrence *et al.*, 1998) and social ranking (Hessing *et al.*, 1994b).

#### 1.3.3.4 Respiratory disease

Respiratory disease has been suggested to have a possible severe negative effect on pig welfare (Blaha, 1993). The most prevalent respiratory diseases are enzootic pneumonia, which is caused by infection with *Mycoplasma hyopneumoniae* and common on a high proportion of farms and pleuropneumonia, found on a lower proportion of farms and caused by the pathogen *Actinobacillus pleuropneumoniae* (Stark, 2000). Prevalence of respiratory diseases is often diagnosed by using a 'cough' index (Straw 1986a; Bahnson *et al.*, 1994) but diagnosis using just these clinical signs has reported to be only 70 per cent effective (Sorenson *et al.*, 1993) and is not considered to be a good indicator of severity (Straw *et al.*, 1990). More accurate is the determination of levels of gross pathological lesions detectable at slaughter (Christensen and Mousing, 1992). In order to diagnose the respiratory health it is recommended that at least 30 lungs need to be inspected (Straw *et al.*, 1986b; Pointon *et al.*, 1990; Davies *et al.*, 1995) and that the degree of damaged lung should be calculated as a percentage of total lung volume (Morrison *et al.*, 1985).

There is a wide range of environmental factors that affect the prevalence of respiratory disease on a farm, which are either due to increased risk of exposure to infection or the decrease in the ability of pigs to cope with the infection. Factors that increase risk of exposure include increased herd size, increased stocking density, shared airspace, housing type, pen hygiene, animal movement and reduced distance to a possibly

infected farm (Stark et al, 1998; Hurnik *et al.*, 1994). Factors reported to potentially influence the ability of pigs to cope with respiratory infection include heating (Elbers, 1991), intermittent draughts (Scheepens *et al.*, 1991b), air temperature (Stark *et al.*, 1998; Tuovinen *et al.*, 1997) and toxic gases (Tuovinen *et al.*, 1990).

#### 1.3.3.5 Acute phase proteins

The acute phase response is a non-specific, early response of an animal to infection and inflammation (Heergaard *et al.*, 1998). It is made up from a range of systemic reactions including fever, increase in muscle protein catabolism, alterations in sleep patterns and appetite, and induction of a group of serum proteins called acute phase proteins (Heergaard *et al.*, 1998). Acute phase proteins are produced by the liver in response to cytokines associated with inflammation, infection or tissue injury and function to restore homeostasis in the body following injury or infection (Holck *et al.*, 1998). Thus an increase in acute phase protein concentration has been suggested to be useful in the detection and monitoring of diseases causing inflammatory conditions in farm animals, particularly pigs (Eckersall *et al.*, 1996; Heergaard *et al.*, 1998). This may also be important in preventative veterinary medicine (Touissant *et al.*, 1995) and also in ante- and post-mortem (Saini and Webert, 1991).

Suitable candidates for study include Haptoglobin, C-reactive protein, Major Acute Phase protein and Serum Amyloid A as they have all been identified as sensitive indicators of infection (with *Actinobacillus pleuropneumoniae*) (Heergaard *et al.*, 1998). There is little information as to what environmental factors are important in

influencing levels of acute phase proteins. Those found to be important include increased pen density, weaning age, and medicated early weaning (Francisco *et al.*, 1996a; Francisco *et al.*, 1996b). Pigs kept under research conditions had lower serum haptoglobin levels than those kept under commercial conditions (Holck *et al.*, 1998). Pigs with increased serum haptoglobin have been reported to have reduced weight gain compared to pigs not showing an acute phase response (Eurell *et al.*, 1992).

## **1.4 Behavioural assessment of pig welfare**

### *1.4.1 General information*

Physiological responses to stressors are generally considered difficult and expensive to measure in pigs, particularly under commercial circumstances (Dybckjaer, 1992). In response to stressors animals also react behaviourally and this change in behaviour has been suggested to be a useful method of evaluating stressors (Moberg, 1985). Behavioural studies of stress responses (and therefore welfare assessment) are inexpensive, relatively easy to carry out and do not expose animals to additional stressors such as blood sampling which may confound results (Dybckjaer, 1992).

### *1.4.2 Normal behaviour*

In order to interpret what the behaviour of an animal ‘means’ in terms of its welfare it is necessary to have a detailed knowledge of the behaviour characteristic of an animal species (Mench and Mason, 1997). The behaviour of the pig under natural conditions has been suggested as being optimal for its welfare (see Section 1.1.3) and Section 1.2 gives an account of such behaviour. However, when considering behavioural needs (see Section 1.2.1) it has been suggested that only the performance of certain behaviours are important in regulating welfare (Dawkins, 1983a). When considering Dawkins’ application of consumer demand theory to animal behaviour and welfare (see section 1.2.2.4), Hughes and Duncan (1988) suggest that some elasticity of behaviour is important in regulating welfare. For example, they describe the animal kept in a barren environment in which externally controlled behaviour (e.g. foraging) is not elicited and

when essential maintenance activities are performed in a relatively short time (e.g. pigs fed high density diets - see Section 1.2.3.1) then it is important for the animal's welfare that there is an elastic component of behaviour, the performance of which is neither detrimental to the animal nor to others, which can expand to fill the available time.

#### *1.4.3 Behavioural indicators of pain or distress*

Archer (1976) lists a number of behaviours indicating fear and distress including escape and avoidance, immobility or protective responses and distress signals. Fraser and Broom (1990) suggest that behavioural characteristics are the most valuable indicators of pain, particularly information concerning food and water intake, defecation, vomiting, posture, ease of movement and responsiveness to various stimuli. They suggest that a prime indicator of pain in pigs is a reluctance to move.

##### *1.4.3.1 Vocalisations*

Vocalisations are another important indicator of pain or distress in pigs. Xin *et al.* (1989) suggested that the degree of pig stress might be distinguished according to variation in the acoustical characteristics of vocalisations in terms of duration and frequency, with increased stress resulting in longer duration and higher frequency calls. Piglets have been reported to produce distinctive distress calls when isolated from the sow (Fraser, 1974). These distress calls have since been reported to vary according to the piglets' state. Hungry or slow-growing piglets call more and use calls of longer duration that are louder and of a higher frequency (Weary and Fraser, 1995), as do

piglets kept at 14°C relative to those kept at 30°C (Weary *et al.*, 1997b). Wemelsfelder and van Putten (1985) used a variety of behavioural indicators in order to ascertain the effects of castration on the welfare of piglets. They found increased frequencies in the screams of castrated pigs compared to those subjected to just normal handling and found that male castrated piglets took longer to lie down, were less active and showed more trembling than females and concluded that the castrated piglets were in pain and had reduced welfare for a number of days following the procedure.

#### 1.4.3.2 Behavioural repertoire

Changes in the time spent performing certain behaviours have been used as indicators of stress in pigs. Dybkjaer (1992) found that there was an increase in redirected oral behaviours and passive sitting in pigs exposed to environmental and social stressors and suggested that these are effective behavioural indicators of stress. Passive sitting has been suggested to be an inactive “cut off” strategy enabling pigs to protect themselves from the physiological effects of stress (Pearce *et al.*, 1989). The welfare of an animal has been suggested to be reduced when injured by another, pursued by another or has its movements restricted by a dominant animal (Fraser and Broom, 1990) implying that increased aggression will result in reduced welfare. Aggression is increased when there is increased competition for resources (Ewbank and Bryant, 1972) and is directly responsible for reduced welfare but it has also been used as a sign of poor welfare. Frustration in pigs due to unpredictability of environmental changes results in increased aggression in the presence of aggression-eliciting stimuli (i.e. other pigs) and so levels of aggression can be used as an indicator of psychological stress (Arnone and Dantzer,



1980; Carlstead, 1986). It has been proposed that abnormal inactivity or a lack of responsiveness are signs of reduced welfare (e.g. Fraser and Broom, 1990) and Broom (1987) suggests that such behaviour indicates that an animal is having to modify its normal functioning in order to cope with its environment. Behavioural vices and stereotypies have also been suggested as suitable indicators of reduced welfare.

#### *1.4.4 Aggression and avoidance behaviour*

Ewbank and Bryant (1972) suggested that between 74% and 93% of aggressive acts between pigs were resource related. Meese and Ewbank (1973) showed that unstable groups showed a high frequency and intensity of resource-related aggression as compared to stable groups. This difference in social behaviour can be explained in terms of the social space requirements of the pigs under the different conditions.

Jensen (1982) reported that unfamiliar pigs, when housed at a high stocking density established a less stable dominance hierarchy than a similar group housed at a lower stocking density. This resulted in an overall increase in aggression between individuals. This report suggested that this increase in aggression was due to inadequate space, which interfered with the most common form of pig aggression, parallel/inverse pressing (shown to be 44% of aggressive behaviour) where the pigs push each other shoulder to shoulder facing in the same or opposite directions. For the pigs to carry out this action they would need almost two body lengths of clear space. This component of pig aggression usually occurs in the middle of a fight before a social rank relationship has been established. This means that if a fight is interrupted before its conclusion (due

to lack of space for the contest), it would have to be repeated or the ranking would be left unestablished.

Another aspect of socio-dominance behaviour in pigs is the major component of submission. The subordinate pig in a fight must submit before the dominant pig will cease attacking it. If the pen is too small/crowded to allow adequate room to retreat, the fight will continue at major cost to the subordinate (McGlone and Curtis, 1985). McGlone and Curtis (1985) have reported that the provision of pop-holes in the wall into which a pig could insert its head and shoulders would foreshorten fights by 40% and reduce injury from fighting by 50%.

Complexity of the rearing environment appears to be important in mediating agonistic behaviour in pigs. Pigs reared in barren conditions show increased aggressive behaviour in later life (De Jonge *et al.*, 1996) compared to those reared under more enriched conditions. Increased space allowance during early rearing is important in the normal development of social behaviour with respect to learning signs of dominance/submission (Schouten, 1986).

Establishment of the dominance hierarchy takes place every time groups of pigs are mixed, which may include a change of accommodation (Petherick and Blackshaw, 1987). Re-mixing is the main cause of aggression in pig rearing (Petherick and Blackshaw, 1987). Other factors resulting in increased aggressive behaviour are

inadequate number of drinkers (Turner *et al.*, 1999) and restricted feeding (Kelley *et al.*, 1980). Environmental enrichment has been reported to reduce aggressive episodes between pigs (Schaefer *et al.*, 1990; Simonsen, 1990; Petersen *et al.*, 1995). Kelley *et al.* (1980) found that provision of straw reduced aggression in restricted-fed pigs but did not inhibit the effects of overcrowding on increased aggression. Another study found no effect of straw on fighting between newly mixed growing pigs (Arey and Franklin, 1995).

Pheromonal communication is also important in influencing aggressive/avoidance behaviour (see section 1.2.5.3).

#### *1.4.5 Abnormal behaviour*

Dawkins (1980) suggested that abnormal behaviour may be an indicator of reduced welfare. However, she uses the term 'abnormal' to describe exceptional, irregular or unusual which can include a wide range of behaviours. As an indicator of welfare Duncan and Dawkins (1983) define abnormal as a persistent, undesirable action, shown by a minority of the population which is not due to any obvious neurological lesion and which is not confined to the situation that originally elicited it. It has also been suggested that abnormal behaviour should be maladaptive or damaging to the animal (Duncan and Dawkins, 1983).

Wiepkema (1983) lists some of the abnormal behaviours seen in farm species: detrimental behaviours (possibly derived from aggressive, feeding, grooming or other behavioural systems) such as urine drinking or tail biting, stereotypic behaviour, vacuum behaviours, apathetic behaviour, escape and redirected activities.

#### 1.4.5.1 Stereotypic behaviour

Stereotypic behaviour has been defined as a repeated, relatively invariable sequence of movements which has no obvious purpose (Fraser and Broom, 1990). Borell and Hurnik (1991) describe a number of stereotyped behaviours of pigs which are predominantly oral activities either directed towards the environment, such as chewing, licking or pushing of bars, feeder, drinker or other pen fittings; or self-directed, such as tongue rolling, vacuum chewing or chomping. Stereotypic behaviour is found most often where animals are confined and where their behaviour is restricted (Mason, 1991) and it has been suggested that the frustration of specific motivational systems, or the resulting aversion, may underlie stereotypies (Rushen *et al.*, 1993). Cronin (1985) reported that the performance of stereotypies by tethered sows was associated with the release of endogenous opioids and suggested that they functioned as a strategy to cope with an adverse environment. However a subsequent study found no such effect (Rushen *et al.*, 1990). Borell and Hurnik (1991) reported that stereotypic behaviour in gestating sows was associated with an increased adrenocortical sensitivity to an injection of ACTH and concluded that the performance of stereotypies was not a mechanism by which animals cope with an environment of low complexity. They also suggested that a lower adrenocortical response and a failure to develop stereotypic behaviour of sows did not

necessarily mean that they were not affected by their housing conditions. Dantzer and Middleman (1993) proposed that as these opiates have modulatory influences on dopaminergic neurons, which are likely to be involved at some level in the development of stereotypies, it is unlikely that there is any rewarding or self-narcotising properties of stereotypies rather that the increase in opioids is due to some other physiological response to a stressor. Therefore, it is still unclear as to why animals are motivated to perform stereotypies.

#### 1.4.5.2 Behavioural vices

The occurrences of behavioural abnormalities such as tail biting and belly-nosing have been suggested to indicate that the animal carrying out such behaviour and, usually, the recipient are suffering from reduced welfare (Broom, 1996).

Fraser and Broom (1990) describe the process of tail biting:

*“The behaviour first appears with a pig taking the tail of another crossways into its mouth and chewing on it lightly. The animal receiving this attention usually tolerates it. In due course the tail-biting attention becomes more severe with resultant wounds on the tail and haemorrhage.... (Fraser and Broom (1990) and Arey (1991) both suggest that this haemorrhage may cause increased active tail biting by the ‘tail-biter’ and by other pigs in the group).....The injured tail becomes progressively eaten away to its root. At this point associating tail-biting pigs may begin to bite the afflicted animal another parts of the body such as the ears, the vulva and parts of the limbs. All this behaviour is associated with much unrest in the pen-mates. A pig injured as the result of excessive biting becomes submissive and then depressed in behaviour, reacting only slightly to*

*being bitten. Wounds may become contaminated with infection resulting in abscessation of the hindquarters and the posterior segment of the spinal column. Secondary infection may occur in the lungs, kidneys, joints and other parts as a result of pyaemia."*

A number of authors have suggested that it is the psychologically unstimulating conditions associated with intensive housing that is responsible for the onset of tail-biting. Wood-Gush and Vestergaard (1991) suggest that in unstimulating environmental conditions piglets redirect endogenous exploratory behaviour towards their littermates, a hypothesis supported by the findings of others (McKinnon *et al.*, 1989; Beattie *et al.*, 1995b). However, a number of other factors have been found to be associated with an increase in tail biting including noxious gases, disease conditions, diet, high stocking density and draughts (Putten, 1969; Fraser, 1985; Fraser and Broom, 1990; Arey, 1991). Blackshaw (1981) suggests that tail-biting spreads quickly through visual communication. Arey (1991) states that tail-biting is more common in pigs which are disturbed or uncomfortable and in pigs which become restless, discontented or stressed.

#### *1.4.6 Behavioural testing*

##### *1.4.6.1 Open-field testing*

The open field test has been used extensively in rodents (Archer, 1973). During an open field test, an animal is placed in an open area and the behaviour of the animal is monitored. Behaviour in a novel environment, for example exploration or locomotion, has been suggested to be associated with emotions of the animal like fear or excitement (Lawrence *et al.*, 1991; Hessing *et al.*, 1994a). In pigs, these include vocalisations, locomotion levels and levels of defecation/urination (Fraser, 1974). Increased levels of

vocalisations and locomotion scores tend to be related and reflect increased levels of anxiety in pigs (Fraser, 1974). Although defecatory behaviour is common in open-field tests it is not associated with these other behaviours (Fraser, 1974), as it is in rats (Archer, 1973). As mentioned in section 1.4.3.1 the level and type of vocalisations may give an indication as to the apparent “stressfulness” of the experience of being isolated in a novel environment. Borell and Ladewig (1992) found that the pigs that were more active and performed more vocalisations in an open-field test also showed the greatest adrenocortical response.

Grandin (1990) found that pigs reared in a barren environment showed higher levels of excitability in an open-field test than those reared under more enriched conditions. However, Pearce and Paterson (1993) found no effect of rearing in barren or enriched conditions on behaviour in an open-field test. Taylor and Friend (1986) found that pigs reared on concrete floors grazed and rooted at a greater intensity than pasture-reared pigs in pasture novel to both groups.

#### 1.4.6.2 Novel object testing

Responses to novel stimuli utilise other types of tests, such as introducing a novel object into a pen, and giving the animal the opportunity to leave the cage and explore unfamiliar surroundings. A number of studies have reported that pigs from barren environments were more likely to approach and interact with a novel object than those from more enriched environments (Stolba and Wood-Gush, 1980; Wood-Gush *et al.*,

1990; Wood-Gush and Vestergaard, 1991; Pearce and Paterson, 1993; Beattie *et al.*, 1995b; De Jong *et al.*, 1998). Wood-Gush and Vestergaard, (1991) used this evidence for their suggestion of their being an endogenous motivation to explore the environment in pigs (see section 1.2.4.3). Rasmussen (1991) reported that pigs reared in conventional indoor pens reacted to a novel object within the home pen significantly more than pigs reared outside at lower stocking densities. He also found that pigs showing more exploratory behaviour that was directed towards the novel object showed a reduction in adrenal cortex area.

#### 1.4.6.3 Human approach testing

An additional test measuring the response of animals to humans is a "standard human approach test" used in numerous species including pigs to determine levels of fear (Hemsworth *et al.*, 1993). It has been found that pigs showing increased fear of humans by performing increased avoidance behaviour also showed reduced productivity (Hemsworth *et al.*, 1981; Hemsworth *et al.*, 1986). Studies have shown that regular aversive handling of pigs can lead to increased avoidance of humans and increased serum cortisol levels (Barnett *et al.*, 1983; Hemsworth *et al.*, 1981; Hemsworth *et al.*, 1986; Hemsworth *et al.*, 1987). However this has not been found in all studies (Paterson and Pearce, 1989, 1992; Pearce *et al.*, 1989; Hemsworth and Barnett, 1991).

Factors found to reduce human approach behaviour are rearing in an environment enriched with toys compared to a conventional pen (Pearce *et al.*, 1993), rearing without human contact (Hill *et al.*, 1998) and human posture (Miura *et al.*, 1996).



#### 1.4.6.4 Animal handling tests

Animal handling is an important part of stockmanship and the quality of that handling can be important in mediating a pigs' wellbeing (Hemsworth *et al.*, 1993). The response of the pig to handling is therefore important in dictating the nature of this contact. Previous studies have shown that provision of natural light, previous moving experience, rearing in a barren environment and reduced human contact are all important in improving the ease of handling of pigs (Grandin *et al.*, 1987; Grandin, 1993; Hunter *et al.*, 1994; Abbott *et al.*, 1997; Hunter *et al.*, 1997; Geverink *et al.*, 1998c; Geverink *et al.*, 1999).

## 1.5 Discussion

### *1.5.1 The welfare of pigs*

It is clear that animal welfare is a subject of ever-increasing public concern, particularly the well-being of animals kept under intensive rearing conditions where it might be argued that there is more cost to the animal imposed by farmers. As more research is carried out into this area, it becomes more apparent that farmed species do display levels of intelligence and cognition beyond what was generally accepted to be the case. The domestic pig has particularly been identified as being an animal with a wide behavioural repertoire including exploratory behaviour, social structure, social learning and others demonstrating its intelligence. It has also been identified as one of the farmed species where there is increasing disparity between its physical and behavioural needs and those imposed in commercial practice.

In order to establish what can scientifically be regarded as good and what is poor welfare there has been a series of attempts to define the word “welfare” with regard to an animal. It is generally accepted that welfare should be regarded as an encompassing term for a combination of psychological state, physical health and biological fitness of an animal, although contradictions still exist. The difficulty in the assessment of welfare has been the subjectivity involved in this area. In order to try and make this science more objective definitions such as that of Broom (1986) are useful. The idea of the ability to cope allows direct measurements of behavioural and physiological indicators in order to determine whereabouts on the continuum of poor to good welfare does a

particular animal or particular environmental condition exist i.e., the more effort has to be put into adaptation, the poorer animal welfare. However, this does not allow for the direct comparison of individual indicators of welfare, such as how does a severe respiratory infection compare with a high level of stereotypic behaviour.

In order to have some benchmark to which welfare standards can relate the Five Freedoms have been introduced. The Five Freedoms were originally created as a result of basic research into animal science, including some early studies of animal welfare and hypotheses devised according to what may be described as anthropomorphic thinking. These guidelines have subsequently changed according to the findings of new research but it is generally accepted that there is still a lot to be discovered in the field of animal welfare science.

### *1.5.2 Physiological indicators of welfare*

Important physiological signs in the assessment of welfare are those that are associated with a response to some form of stressor, which may result in chronic stress. These initial responses include such indicators as an increase in heart rate, but it is generally accepted that it is chronic stress that is a major animal welfare problem, particularly in intensively housed animals, such as pigs. Chronic stress has direct negative effects on productivity through altered partitioning of energy. It also can impair immune function, which has an important role in the prevention of pathogenic infection. Ill health has been suggested to be the most important factor in reducing pig welfare and the intensive rearing methods utilised in commercial practice are associated with high levels of disease, particularly enteric and respiratory conditions. The rearing environment of pigs

has been shown to be important in mediating the physiological response of pigs to stressors and also in influencing the prevalence of diseases, which have direct effects on each other. Other important physiological indicators include skin lesions and foot damage.

### *1.5.3 Behavioural indicators of pig welfare*

The behavioural responses of pigs are considered to be the best indicator of psychological wellbeing, considered by some to be of sole importance when determining a level of welfare. It is the restriction of behaviour imposed by intensive housing conditions that was first recognised as being detrimental to pig welfare. Although behavioural needs are not thought to be essential for the continuation of life, such as food and water might be regarded, their deprivation is still suggested to cause suffering. Behavioural needs stem from mechanisms evolved to drive animal behaviour. This concept, termed 'motivation', has resulted in several theories of how these mechanisms work, particularly with regard to the importance of internal and external stimuli. Some theories suggest that the actual performance of a behaviour pattern is important in the normal functioning of the animal and it is this reason that behavioural needs exist. An important motivation found to exist in pigs is that of exploration of the environment. It is the frustration of this need by the lack of stimuli in most housing systems, particularly those that do not provide a rooting substrate for all pigs or material for nesting for periparturient sows.

Although alterations from the natural behavioural repertoire are considered to be the primary indicators of reduced welfare in pigs, this study of behaviour is difficult to carry

out on large numbers of animals in a variety of housing systems. Useful alternatives include the behavioural responses of animals to stressors such as regrouping, isolation, novelty, response to humans and animal handling, which can be used to determine emotional states. Rearing environment is thought to be important in mediating these responses.

#### *1.5.4 Assessment of pig welfare under commercial conditions*

There are a wide variety of housing systems for rearing pigs, particularly in the UK. It is therefore important to carry out welfare assessments on a range of rearing environments by using as many indicators of welfare as possible. In order to maximise the usefulness of the data it is important to utilise multivariate statistical techniques in order to determine the factors within the rearing environment that influence pig health and welfare and their relative importance. This would then allow the future construction of an animal welfare indices that can be used for the recommendations for housing designs and management methods in order to maximise pig welfare. Producers interested in high welfare can then adopt these standards to provide for the discerning modern-day consumer.

## 1.6 Aims of the study

The aim of this study was to identify factors within the rearing environment of growing pigs that influenced the health and welfare of growing pigs. From the literature review a working definition of welfare has been identified for use in this project (Broom, 1986) and suitable indicators, behavioural and physiological, for its assessment. Factors considered to be beneficial as well as detrimental, likely to be linked to pig welfare have been identified, particularly those influencing behavioural development and the prevalence of disease.

The study was initially carried out on commercial pig farms looking at a range of environmental and management parameters and their effects on human approach behaviour and clinical signs of disease. This was followed up by a study in lairage of behaviour during handling, agonistic behaviour in the lairage pen and physiological signs of welfare and relating this data to factors within the rearing environment. Following slaughter additional indicators of welfare were measured, including bursitis and gastric ulceration. The work continued by assessing other indicators of welfare related to health, such the prevalences of common respiratory diseases and the use of recently proposed indicators of health, acute phase proteins. The presence of straw bedding was identified as being important as positively affecting a number of indicators of welfare as was the importance of particular rearing periods. Therefore, a controlled study was carried out to examine the effects of providing straw during different rearing periods on immune function and adrenocortical response as well as behavioural responses to certain stressors. In addition, an investigation was carried out into the potential impact of alarm pheromones on pig welfare, again through behavioural testing.

## CHAPTER 2. INFLUENCE OF HUSBANDRY SYSTEM ON HUMAN APPROACH BEHAVIOUR IN GROWER-FINISHER PIGS.

### 2.1 Introduction

The importance of the quality of the human-animal relationship on the productivity and welfare of commercial farm animals is now well established. Work by Hemsworth and others in Australia using commercial pigs found that significant negative correlations existed between various measures of productivity and avoidance behaviour of a human subject (also termed human approach behaviour) (Hemsworth *et al.*, 1981; Hemsworth *et al.*, 1986). On the basis of these findings it was suggested that a chronic physiological stress response was responsible for the depression in productivity (Hemsworth *et al.*, 1986). Aversive handling treatments which resulted in increased avoidance behaviour towards humans have been associated with a general sustained elevation of free corticosteroid concentrations and a reduction in growth and reproductive performance in pigs (Barnett *et al.*, 1983; Hemsworth *et al.*, 1981; Hemsworth *et al.*, 1986; Hemsworth *et al.*, 1987). However, a number of studies reported no relationship between avoidance behaviour and growth or physiological evidence of chronic stress as a result of aversive handling (Paterson and Pearce, 1989, 1992; Pearce *et al.*, 1989; Hemsworth and Barnett, 1991). These studies have shown that the effects of handling on production are variable. This may be due to the differences in handling regimes imposed on the pigs but it is likely that there are other aspects of the physical and social environment causing this variation in findings. Rushen *et al.* (1999) suggest that factors that can modify the relationship between handling and production clearly need to be identified and investigated.

It is generally agreed that an increase in avoidance behaviour is indicative of increased fear of humans (e.g. Hemsworth *et al.*, 1981; Pearce *et al.*, 1989). It has also been suggested that the welfare of animals displaying high levels of fear of humans is at serious risk in production systems in which they are in frequent contact with humans (Hemsworth *et al.*, 1993).

Although extensive research has been directed at the investigation of the effects of the quality of stockmanship on human approach behaviour (reviewed by Hemsworth *et al.*, 1993) there has been little research into other factors regulating the response of pigs to humans. Pigs reared in an environment enriched with toys (Pearce *et al.*, 1989) and pigs fed in the presence of a human (Hemsworth *et al.*, 1996) have been reported to show less avoidance behaviour towards humans. Other important modifiers of pig behaviour include temperature (Geers *et al.*, 1989), draughts (Sheepens *et al.*, 1991), group and pen size (Moore *et al.*, 1994), space allowance (Pearce and Paterson, 1993) and the use of straw bedding (De Jong *et al.*, 1998). Particular husbandry systems and environments are therefore expected to be of importance in mediating human approach behaviour although, to date, there has been little research in this area.

An increase in avoidance behaviour is generally accepted to be indicative of increased fear of humans (e.g. Hemsworth *et al.*, 1981; Pearce *et al.*, 1989). It has also been suggested that the welfare of animals displaying high levels of fear of humans is at serious risk in production systems in which they are in frequent contact with humans



(Hemsworth *et al.*, 1993). Due to the importance of the human-animals relationship on the productivity and welfare of pigs it has been suggested that there is a need for research in this area (Hemsworth *et al.*, 1996; Rushen *et al.*, 1999).

The present study was designed to determine which environmental and husbandry factors on various commercial units were important in mediating the response to humans of grower-finisher pigs.

## 2.2 Methods and Materials

This study was carried out between 19/3/97 and 5/9/97 on 27 commercial breeder/finisher pig units in the counties of Shropshire, Staffordshire and Cheshire in England. Each farm was visited once and the following information was collected through personal interview with the farmer or direct observation of the pigs/buildings.

(“Weaners” include pigs from weaning-20 kg, “growers” 20-45 kg and “finishers” 45-90 kg.)

### *2.2.1 Husbandry methods recorded*

1. Herd size, farrowing accommodation (outdoor arc/ farrowing crate) and age at weaning.
2. Type of weaner accommodation (straw bedding/ solid floor without straw/ slatted floor/ kennelled area with external slats/ expanded metal floor/ other).
3. Dunging and lying area floor type used for growers and finishers (deep-straw or straw on concrete floor/ concrete floor/ slatted floor).
4. Size of pens (lying and dunging area), size of groups and space allowance (weaners, growers and finishers).
5. Feeder space (length of trough and length of trough/ pig)
6. Water availability - (number of nipple drinkers and number of pigs/nipple drinker or pigs/drinking bowl). If nipple drinkers were the water source their rate of flow was determined. If bowl drinkers were provided their refill rate was determined.

## 7. Management factors

- i) Feeding method (automatic/ manual)
- ii) Feed type (wet fed / meal diet/ pelleted diet)
- iii) Ventilation type (natural/ fan assisted)
- iv) Dung disposal (slats and drains/ manual (tractor or by hand))

### 2.2.2 Environmental factors

All environmental data were measured at the same time of day on each unit, approximately 11.00 hours for the growers and 13.00 hours for the finishers.

8. Temperature and humidity - the ambient temperature in the lying and dunging area of one pen in the grower house and one in the finisher house were recorded hourly over a 1 week period using Tinytalk II<sup>®</sup> temperature data logger (Gemini Dataloggers UK Ltd.) In addition spot temperature and humidity readings were taken in the centre of the lying and dunging areas of eight pens in grower house and eight pens in the finisher house using an humidity and temperature meter (HM4 from Vaisala Ltd, UK).

9. Ammonia concentration - this was recorded instantaneously in the centre of the lying and dunging areas of eight pens in grower house and eight pens in the finisher house using a Multiwarn II<sup>®</sup> sensor (Dräger Ltd., UK).

10. Airflow - The maximum airflow in a 1 minute period a vane-anemometer (an AV2<sup>®</sup> Air Velocity and Volume Flow Meter from Airflow Developments Ltd.) was taken from the middle of the lying area and the middle of the dunging area of 8 pens in each house at just above pig level.

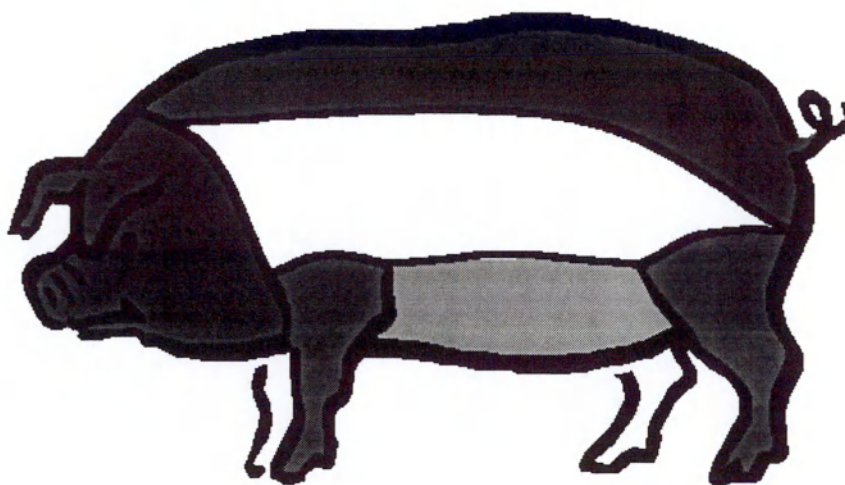
### 11. Pig and pen cleanliness:

Twenty-five pigs from at least ten grower pens and 25 from at least ten finisher pens were chosen as a representative sample and assessed for cleanliness according to the following system. For the purpose of this assessment the pig was divided up into the following areas: front legs, hind legs, belly, left flank, right flank, head, back and hind-quarters (see figure 2.1). Each of these areas was given a cleanliness score of 0-5 based on the percentage of skin surface covered by faeces (see table 2.1). This gave an overall score of between 0-40. Observer differences were minimised by using the same observer in all cases.

For each pig selected for the cleanliness scoring, the cleanliness of each of the 10 pens was given a score from 0-10 based on the percentage of the pen surface covered by faeces, 0= no faeces, 1= 10% covered and 10= 100% of floor covered.

**Table 2.1 The scoring system used to estimate the cleanliness of each section of the pig's surface area in order to give an overall score.**

Cleanliness score	% surface area covered in faeces
0	0
1	20
2	40
3	60
4	80
5	100



**Figure 2.1** A diagram to show how the surface area of the pig was divided in order to give cleanliness scores in the farm survey.

### *2.2.3 Human-approach test*

The behavioural responses of eight groups of grower pigs and eight groups of finisher pigs to the presence of a human observer were recorded. This was based on the method reported by Hemsworth *et al.* (1981). A human quietly entered the pen and stood erect against the mid-point of the end of the pen designated as the dunging area. The area 0.5m from his boots was marked using a spray marker. During the next 3 minutes the pigs were observed for:

1. Latency to 1 pig entering within 0.5m of the human observer (nose enters 0.5m area).
2. Latency to 1 pig physically interacting (e.g. nasal contact, bite, lick) with the human observer.
3. Latency to 25% of the pigs in the pen interacting with the human observer.

The human-approach test was repeated for 7 other pens throughout the house chosen as a representative sample (i.e., away from entrances and spread throughout the house).

### 2.3 Statistical analysis

All approach times were transformed according to the formula  $\ln(x+0.1)$  in order to fit normal distribution patterns. Multiple regression models were constructed for the dependent variables (latency for 1 pig to approach 0.5m, latency for 1 pig to make contact with a human subject and latency for 25% of pigs). In order to determine which terms were to be considered for the construction of a multiple regression model univariate analyses of variance were carried out between individual farm factors and the dependent variables. Those terms giving an F-probability  $P < 0.25$  were put forward for the multiple regression model as suggested by Hosmer and Lemeshow (1989). Similarly for the continuous independent variable, those giving correlations of  $r > 0.23$  (equivalent to  $p < 0.25$  with 26 degrees of freedom based on 27 farms) were also put forward for the multiple regression model. None of these subsequent independent variables were found to be highly correlated with each other ( $r < 0.8$ ) and so all were considered together in a multiple regression model for each of the dependent variables. This was carried out using a forward stepwise selection procedure including (or dropping) terms with a variance ratio greater than or equal to 4. All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

## 2.4 Results

The median, minimum and maximum values in human approach behaviour (not normally distributed) in the 27 farms involved in this study are presented in table 2.2.

The descriptive results for the continuous variables and other husbandry data are presented in tables 2.3 and 2.4, respectively. Table 2.5 shows the final multiple regression models for each of the human approach dependent variables for the grower and finisher pigs.

**Table 2.2 The descriptive results for the independent variables recorded from the 27 farms in this study.**

Independent variable	median		range	
number of sows	200		56 - 800	
weaner group size	25		8 - 70	
weaner pen size (m <sup>2</sup> )	5.1		0.8 - 32.5	
weaner space allowance (m <sup>2</sup> /pig)	0.22		0.08 - 0.72	
weaner temperature (°C)	23.0		17.0 - 28.0	
weaner humidity (%rh)	66.0		39.0 - 95.0	
weaner ammonia concentration (ppm)	0.0		0.0 - 6.0	
	GROWERS		FINISHERS	
	median	range	median	range
Group size	28	15 - 80	19	10 - 80
pen area (m <sup>2</sup> )	18.1	4.3 - 50.2	14.2	8.1 - 46.0
lying area	12.0	1.3 - 33.6	10.8	3.6 - 28.0
dunging area	7.3	2.7 - 34.4	5.0	2.3 - 22.6
space allowance (m <sup>2</sup> /pig)	1.94	0.81 - 3.51	1.35	0.48 - 2.64
trough length (m)	1.5	0.5 - 3.3	1.4	0.2 - 9.0
no. drinkers	2.0	1.0 - 6.0	2.0	0.0 - 6.0
no. pigs/drinker	14.0	6.4 - 50.0	12.5	0.0 - 6.3
temperature (°C)				
lying area	21.8	15.4 - 28.2	22.0	16.4 - 28.3
dunging area	19.9	12.9 - 27.8	20.0	15.5 - 46.9
humidity (%)				
lying area	64.5	38.4 - 95.5	67.9	40.4 - 83.6
dunging area	55.8	30.1 - 96.0	61.3	36.8 - 83.9
ammonia concentration (ppm)				
lying area	0.0	0.0 - 32.9	0.9	0.0 - 19.0
dunging area	0.0	0.0 - 21.5	2.4	0.0 - 21.0
maximum air speed (ms <sup>-1</sup> )				
lying area	0.07	0.00 - 0.27	0.07	0.01 - 0.22

dunging area	0.17	0.00 - 0.79	0.15	0.05 - 0.46
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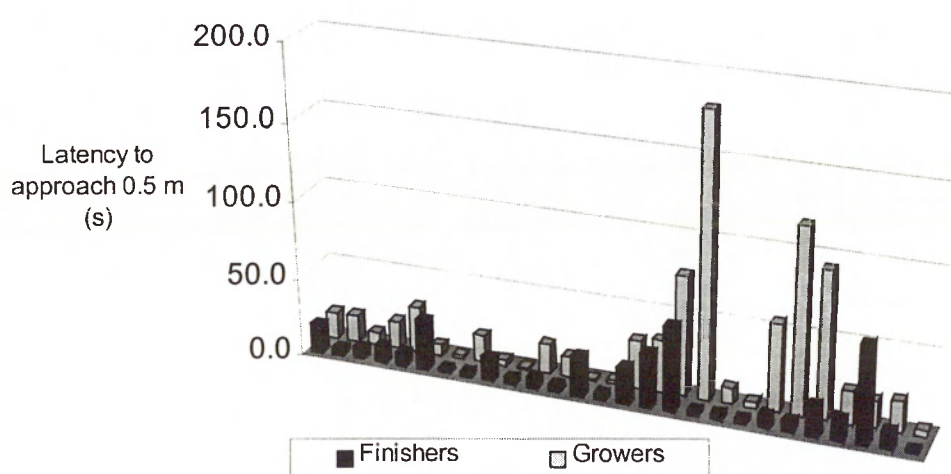
**Table 2.3 Use of different floor types on units studied (% , n=27).**

		Slats	Concrete	Straw
Grower	lying area	44	19	37
	dunging area	26	44	30
Finisher	lying area	37	33	30
	dunging area	26	59	15

**Table 2.4 The median, minimum and maximum values for the latencies for 1 pig to approach, 1 pig to interact and 25 % of the pen to interact in grower and finisher pigs.**

Human Approach Variables (seconds)		Median	Minimum	Maximum
Grower				
Latency to 1 pig entering within 0.5m		17.4	0.8	180.0*
Latency to 1 pig physically interacting		21.8	1.8	180.0*
Latency to 25% of the pigs interacting		46.3	9.6	180.0*
Finisher				
Latency to 1 pig entering within 0.5m		8.1	2.3	61.9
Latency to 1 pig physically interacting		12.8	3.8	72.6
Latency to 25% of the pigs interacting		44.0	14.5	147.9

N.B. 180 seconds/3 minutes was the maximum recorded length of test and indicates that the pigs made no approach/contact

**Figure 2.2 The mean values for each farm for the latencies for one pig to approach to interact in grower and finisher pigs.**



**Table 2.5 The accumulated multiple regression models for the human approach dependent variables for the grower pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Grower approach to 0.5m (ln(s))	Constant <sup>1</sup>	1.053	1.09***	45.2
	+ Grower slatted dunging area	2.255		
	+ Grower straw-bedded dunging area	1.863		
Grower approach to 0.5m (ln(s))	Constant <sup>1</sup>	1.813	0.948***	60.4
	+ Grower slatted dunging area	2.243		
	+ Grower straw-bedded dunging area	1.976		
	+ Grower no. of drinkers	-0.333		
Grower approach to 0.5m (ln(s))	Constant <sup>1</sup>	0.594	0.882***	67.2
	+ Grower slatted dunging area	2.136		
	+ Grower straw-bedded dunging area	2.328		
	+ Grower no. of drinkers	-0.288		
	+ Grower pig cleanliness	0.0998		
Grower first contact (ln(s))	Constant <sup>1</sup>	1.607	0.949***	44.9
	+ Grower slatted dunging area	1.945		
	+ Grower straw-bedded dunging area	1.615		
Grower first contact (ln(s))	Constant <sup>1</sup>	2.269	0.824***	60.2
	+ Grower slatted dunging area	1.935		
	+ Grower straw-bedded dunging area	1.713		
	+ Grower no. of drinkers	-0.2895		
Grower 25 per cent contact (ln(s))	Constant <sup>1</sup>	3.116	0.696***	45.1
	+ Grower slatted dunging area	1.421		
	+ Grower straw-bedded dunging area	0.566		

<sup>NS</sup> non-significant i.e. T-probability > 0.05

<sup>1</sup> adjusted for Grower concrete dunging area

\*\*\* indicates an F-probability of <0.001

**Table 2.6 The accumulated multiple regression models for the human approach dependent variables for the finisher pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Finisher approach to 0.5m (ln(s))	Constant <sup>2</sup>	2.692	0.822**	33.2
	+ Grower slatted lying area	-0.197		
	+ Grower straw-bedded lying area	-1.180		
Finisher approach to 0.5m (ln(s))	Constant <sup>2</sup>	3.509	0.735**	48.8
	+ Grower slatted lying area	-0.427 <sup>NS</sup>		
	+ Grower straw-bedded lying area	-1.260		
	+ Finisher pen area	-0.0402		
Finisher first contact (ln(s))	Constant <sup>2</sup>	3.010	0.772*	31.1
	+ Grower slatted lying area	-0.259 <sup>NS</sup>		
	+ Grower straw-bedded lying area	-1.070		
Finisher first contact (ln(s))	Constant <sup>2</sup>	3.849	0.669***	50.4
	+ Grower slatted lying area	-0.494 <sup>NS</sup>		
	+ Grower straw-bedded lying area	-1.153		
	+ Finisher pen area	-0.0413		
Finisher 25 per cent contact (ln(s))	Not significant			

<sup>NS</sup> non-significant i.e. T-probability > 0.05

<sup>2</sup> adjusted for Grower concrete lying area

\*, \*\*, \*\*\* indicate an F-probability of <0.05, <0.01 and <0.001, respectively

## 2.5 Discussion

This study has identified a number of factors within the rearing environment of the pig that account for a significant proportion of the variation in human approach behaviour (the time taken for a pig to approach and make contact with a human subject) of grower and finisher pigs from a number of different commercial units.

### *2.5.1 Grower models of human approach behaviour*

A concrete dunging area in the grower pen was found to increase the human approach behaviour of grower pigs. On each farm the concrete dunging area was associated with a tractor-drag dunging channel where the pigs were herded into their lying areas by stockmen prior to effluent removal. It is likely that these pigs had increased human contact due to this system compared with the automatic removal of effluent with slatted floors or minimal human contact of deep straw systems. This increased contact may have reduced the pigs' fear of humans due to increased familiarity. This theory is supported by other work showing that pigs kept under conditions of minimal human contact had greatly increased approach latencies and reduced interaction time with a human subject compared with pigs exposed to daily contact and environmentally enriched treatments (Hill *et al.*, 1998). Other studies have also shown that increased contact during rearing can reduce the level of fearfulness of humans by pigs (Tanida *et al.*, 1994; Hemsworth *et al.*, 1996).

An increase in the number of drinkers provided (irrespective of group size) resulted in increased human approach behaviour of growers. It has previously been shown that an reduction in drinker allocation can increase drinker-related aggression and also restrict performance of other behaviours such as play behaviour directed at the drinker (Turner *et al.*, 1999). This potential alteration in behaviour patterns associated with a reduction in drinkers available may have had an effect on the response of pigs to humans. It is possible that stress due to the increased competition/aggression reduced the ability of the pigs to cope with the stressor of a human being present thereby increasing their fear of the human subject.

An increase in the cleanliness of the pigs was associated with increased human approach behaviour. Cleanliness of pigs is associated with eliminative behaviour and lying habits and a poor environment such as overcrowding and heat stress can cause disruption of normal dunging patterns and may alter other maintenance behaviours (McKinnon *et al.*, 1989; Lewis & Christison, 1990). It may be possible that in this survey the higher cleanliness scores (indicating dirtier pigs) were indeed associated with poorer environments, which may also affect human approach behaviour. Again the extra stressors within the environment may have affected the pigs' ability to cope with the stressor of a human being present, increasing its 'fear'.

### 2.5.2 Finisher models of human approach behaviour

Like the grower models, floor type is the most important factor in determining the response to humans of finisher pigs. However, the presence of a straw-bedded lying area at the grower stage increases the human approach behaviour of the finisher pigs compared with those pigs reared previously with a slatted or concrete lying area, these not being significantly different when considering the model concerned with approach latencies to 0.5m. It is clear therefore that the mechanisms that seem to be controlling the behaviour of the grower pigs (i.e. the increased human contact due to husbandry system involved with a concrete dunging area) are not the primary factor mediating the finisher pigs response to humans. Therefore it may be some aspect of the straw bedding which is eliciting the change in human approach behaviour.

Straw bedding has been suggested to have a number of beneficial effects for growing pigs including comfort due to cushioning against sharp or abrasive edges (van Veen *et al.*, 1985), thermal comfort (Stephens, 1971) and a source of environmental enrichment (reviewed by Arey, 1993). It has been previously shown that provision of an environment enriched with toys can increase human approach behaviour (Pearce *et al.*, 1989) compared to a barren environment. However, contrary to their groups' previous findings, Pearce and Paterson (1993) found that pigs reared from 25 to 100 kg in a barren environment showed increased approach behaviour towards both a novel object and a human compared with pigs reared with toys. This increased response may be similar to the concept of 'rebound behaviour', which has been reported in other species,

for example chickens (Vestergaard, 1980; Nicol, 1987) and quail (Schein and Statkiewicz, 1983). It has been shown that rearing in a barren as opposed to a complex environment can cause differences in the brain development of pigs which may be directly linked to the increased excitability seen in pigs reared under barren conditions (Grandin, 1989). This increased excitability may have caused the presence of a human to be a more aversive experience for the pigs reared under more barren conditions as opposed to those reared with access to straw and so causing the increased fear of humans observed in these pigs at the finisher stage.

Evidence from previous studies could explain the apparent differences in the grower and finisher human approach behaviour found in the present study. It has been demonstrated that pigs reared in barren environments spend significantly longer examining a novel object at 5-6 weeks of age than those reared in an enriched environment, but that no differences are apparent at 15-16 weeks of age (Woodgush *et al.*, 1990). This perhaps reflects a change in the motivational state of the older animal. It is possible that the period between weaning and 45 kg, the defined growing period in this study, is an important developmental stage in defining the pigs' response to its environment in later life.

The existence of sensitive or critical periods in an animal's life where there is increased susceptibility to environmental changes in behaviour is a well accepted phenomenon, for example filial imprinting and sexual imprinting (Lorenz, 1935; Bateson, 1979;

Vidal, 1980). The majority of these sensitive periods occur in the animal's early life although they can occur later, for example at parturition in primiparous dairy cows (Hemsworth *et al.*, 1987). It is reasonable to then assume that rearing conditions would be important in behavioural development and this has been demonstrated in a number of species, for example monkeys (Harlow *et al.*, 1962), dogs (Thomson & Heron, 1954; Fuller, 1964), rats (Eschoriheula *et al.*, 1994) and pigs (Schouten, 1987; Pearce and Paterson, 1993; De Jonge *et al.*, 1996; Beattie *et al.*, 1995). Studies of gerbil behaviour by Cheal (1987) indicated that stable behaviour patterns are learned early in life but can be modified by experience. This has been termed "plasticity" of stable behaviour, which Beattie *et al.* (1995) suggested should be more applicable to pigs than simple imprinting. A sensitive period in influencing the development of a behavioural response towards humans in the three weeks after birth has already been identified (Hemsworth and Barnett, 1992). The presence of another sensitive period for behavioural development after weaning may explain the contrary results of previous experiments where the enrichment period of pigs, all from previously barren environments, were carried out over different periods. In the experiment begun at 25 kg (Pearce and Paterson, 1993), enrichment was associated with in reduced human approach behaviour of finisher pigs, whilst when started at 40 kg (Pearce *et al.*, 1989) enrichment resulted in an increase in human approach behaviour of finisher pigs.

An increase in finisher pen area was associated with an increase in human approach behaviour. This is contrary to a previous study which found that pigs kept under crowded conditions showed no difference in human approach behaviour from those kept

under uncrowded conditions (Pearce & Paterson, 1993). However, this study did show that the exploratory behaviour of the uncrowded pigs within the home pen increased compared with those kept under crowded conditions although no difference between treatments was found in a novel object test in a separate pen. This component of variation may therefore be due to an increase in the motivation of the pigs to explore the human within their home pen and so treating the human as a novel object. This may be due to an increase in the ease of movement without encroaching on another pig's personal space and any associated agonistic interaction (Baxter, 1985). Other work has reported the similarity in response to humans and novel objects in pigs (Lawrence *et al.*, 1991) and goats (Lyons *et al.*, 1988). Pearce and Paterson (1993) suggested that caution should be used when interpreting the human approach test as a measure of "fear of humans" when the test may simply reflect the pigs' level of motivation to explore a novel object (i.e. the human).

Previous literature has identified stockmanship as the major factor mediating the human approach behaviour of pigs (reviewed by Hemsworth *et al.*, 1993). However, when considering the behaviour of the first pig in the pen to approach and make contact almost 70 per cent of the variation in approach behaviour can be significantly accounted for using environmental factors alone, without a direct measure of stockmanship. It could possibly be argued that a stockman more concerned with the welfare of his stock might be associated with particular husbandry systems, perhaps a straw-based unit. Therefore the current findings may be due to undetermined associations between the behaviour of the stockman and the environment. However, this is unlikely as the



previous literature has already demonstrated the important effects of environmental enrichment in addition to handling regime (Pearce *et al.*, 1989). It is likely that the rearing environment is equally or even more important than quality of handling in mediating human approach behaviour on commercial units, particularly in systems where actual physical human contact is rare and the quality of that contact fairly consistent between farms.

## 2.6 Conclusions

An increase in grower human approach behaviour was associated with a concrete dunging area, which may be due to increased daily human contact resulting in increased familiarity and a reduction in fear. It is suggested that stressors such as competition for drinkers and a poor environment as indicated by increased dirtiness may have affected the pigs' ability to cope with the stressor of a human being present, increasing its 'fear'.

An increase in finisher human approach behaviour was associated with the provision of straw bedding at the grower stage and it is suggested that this may be due to the environmental enrichment properties of straw that may reduce the pig's fear of humans.

It is proposed that a sensitive period of behavioural development, particularly with respect to response to humans, may exist after weaning and is more important in dictating the response to humans in finisher pigs than their current environment. An increase in finisher pen area was associated with an increase in human approach behaviour, which was suggested to be due to the increase in exploratory behaviour observed in pigs under increasing space allowances. Two primary motivations are suggested to control the human approach behaviour of pigs in this survey, the motivation to retreat from the human subject due to aversion and the motivation to explore the human subject as a source of novelty.

## **CHAPTER 3. INFLUENCE OF ENVIRONMENTAL CONDITIONS AND HUSBANDRY SYSTEM ON SIGNS OF INJURY AND DISEASE IN GROWER-FINISHER PIGS.**

### **3.1 Introduction**

Modern intensive systems designed to improve the economic viability of pig rearing can result in the increased spread of infection (Taylor, 1995). Increased herd sizes and close contact between animals favours a quick passage of pathogens, which may lead to an increase in virulence and an increased infection pressure (Hartung, 1994). The aetiology of disease in intensively housed livestock tends to be multifactorial, arising through an interaction of infection and environmental stress (Webster, 1982).

Common diseases of pigs include enzootic pneumonia, pleuropneumonia, atrophic rhinitis, porcine intestinal adenomatosis (PIA), *E. coli* enteritis and swine dysentery, all of which may result in a reduction in growth performance. For example infection with *Mycoplasma hyopneumoniae*, the organism causing enzootic pneumonia, has been shown to increase the rearing time from birth to 90 kg body weight by two weeks (Wallgren *et al.*, 1993) compared to pigs without infection. Enzootic pneumonia, pleuropneumonia and atrophic rhinitis are respiratory disorders and common clinical signs of infection are coughing and sneezing (Taylor, 1995). *E. coli* enteritis (mainly seen in the neo-natal pig), PIA and swine dysentery are the most common enteric diseases of pigs - enteric disease being the predominant cause of pig diarrhoea (Taylor, 1995).

The pig's resistance to pathogenic infection is regulated by its immune system which has been reported to be influenced by exposure to stressors (Johnson *et al.*, 1994; Wallgren *et al.*, 1994b). Unfavourable climatic conditions have been suggested to be a major source of health problems in pigs (Tielen, 1987). Heat (Machado-Neto *et al.*, 1987; Morrow-Tesch *et al.*, 1994), cold (Blecha and Kelley, 1981) and intermittent draughts (Scheepens *et al.*, 1991) have all been shown to alter the immune function of pigs. Particular husbandry techniques that have been shown to influence immune function including weaning (Blecha *et al.*, 1983; Blecha *et al.*, 1985; Bailey *et al.*, 1992; Wattrang *et al.*, 1998), transport (Dahlin *et al.*, 1993, McGlone *et al.*, 1993) and social regrouping (Wattrang *et al.*, 1994). A number of studies have reported that pigs of a higher social status have improved immune function (increased natural killer cell cytotoxicity) relative to those of lower ranking (McGlone *et al.*, 1993; Hessing *et al.*, 1994b Morrow-Tesch *et al.*, 1994) and that genetic variation also exists in the immune competence of pigs (Edfors-Lilja *et al.*, 1994).

Environmental factors such as overcrowding, diet, changes in humidity and temperature or a barren environment have also been related to behavioural problems such as tail-biting (reviewed by Arey, 1991) and physical injuries indicated by skin lesions. Skin lesion scoring was suggested by Ekesbo and demonstrated by De Koning (1984) to be a good measure of welfare as they indicate inadequate housing conditions resulting in physical trauma from sharp pen fittings and/or heightened aggressive behaviour. It is widely accepted that the health and welfare of an animal have a strong relationship.

Ewbank (1988) suggests that for practical purposes, there is merit in replacing the word “welfare” with the terms “health” and “well-being”. The welfare of diseased animals is poorer than that of non-diseased animals (Broom, 1988) and so signs of injury and disease can be considered to be good indicators for the assessment of welfare.

In order to continue with the measurement of the health and welfare of grower and finisher pigs kept under commercial conditions, this survey was designed to identify which husbandry and management procedures were important in mediating scores of clinical injury and disease in grower and finisher pigs reared under commercial conditions.

## 3.2 Methods and Materials

This study was carried out between 19/3/97 and 5/9/97 concurrently with the study reported in chapter two utilising the same 27 commercial units.

### *3.2.1 Husbandry and environmental factors*

These factors were recorded as stated in the materials and methods section of the previous chapter (sections 2.2.1. and 2.2.2)

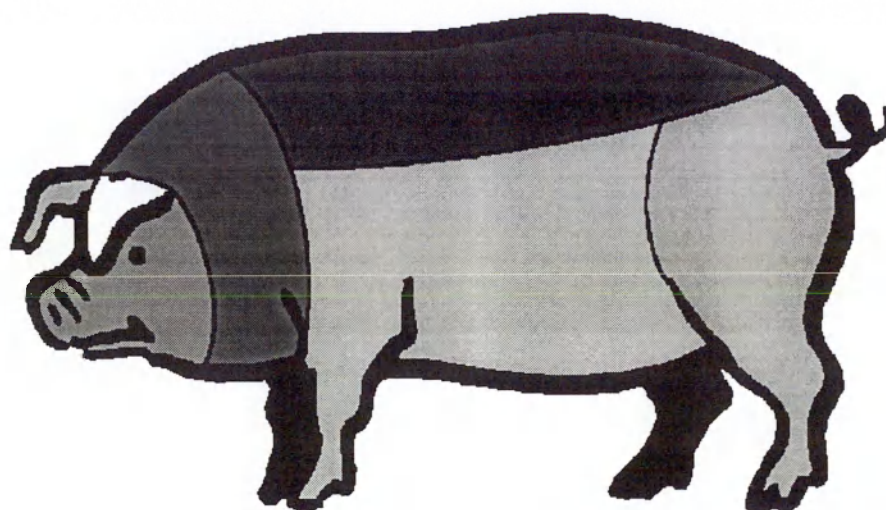
### *3.2.2 Welfare indicators*

#### *3.2.2.1 Coughs and Sneezes:*

An observer entered the pen and roused the pigs until they were all standing. For the following five-minute period a cough and sneeze score was determined. This was calculated by counting the number of coughs and sneezes in a pen and dividing it by the number of pigs. This was repeated for four grower and four finisher pens and a mean score per pig calculated for coughs and another for sneezes (the pens were chosen to be a representative sample of the house, i.e. away from entrances and from both sides and/or ends). Coughing is a good indicator for the presence of enzootic pneumonia in fattening pigs (Morris *et al.*, 1995).

### 3.2.2.2 Skin lesions and tail-biting:

Twenty-five pigs from 10 grower pens and 25 from 10 finisher pens were chosen at random from those that had not been mixed within the previous week. These were examined for skin lesions. A skin lesion was defined as a breakage in the skin. For the purpose of lesion scoring the skin of the pig was divided up into the following areas: face, left ear, right ear, neck (from point between ears to point on back level with front legs), back, left and right flank (sides of pig between front and back leg), left and right hind-quarter (back leg backwards). In each of these areas the presence or absence of lesions were recorded. The skin lesion score for each pig was calculated by determining the total number of areas containing a lesion. This is based on the method of scoring proposed by Ekesbo and used by De Koning (1984).



**Figure 3.1** A diagram to show how the surface area of the pig was divided in order to give skin lesion scores in the farm survey.

Each of the pigs were assessed for signs of tail-biting and given a score from 0-10 according to the system described in table 3.1. A score of 0 was recorded if there was no evidence of tail-biting, 1= 10% of tail damaged, 2= 20 % of tail damaged, etc. i.e. 10= tail completely absent.

**Table 3.1 The scoring system used to estimate tail biting damage in the farm survey.**

<b>Tail biting score</b>	<b>% tail damaged/missing</b>
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100

### 3.2.2.3 Diarrhoea:

Each of the pigs was examined for evidence of diarrhoea (peri-anal staining and/or presence of liquid faeces around anus) which was recorded as present or absent.



### 3.3 Statistical analysis

Cough, sneeze, scour and tail-biting scores were transformed according to the formula  $\ln(x+0.1)$  in order to fit approximate normal distribution patterns. Multiple regression models were constructed as in the previous chapter (section 2.3). All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

### 3.4 Results

The descriptive results for the independent variables recorded from the 27 farms in this study are presented in table 2.1. The median and range of values for the clinical signs of disease (cough score, sneeze score, lesion score, tail biting score, and diarrhoea) and pig/pen cleanliness for grower and finisher pigs are presented in table 3.2. The final multiple regression models for each of the grower and finisher signs of injury and disease are presented in tables 3.3 and 3.4.

**Table 3.2 The median and range of values for cough score, sneeze score, lesion score, tail biting score, pen cleanliness score, pig cleanliness score and diarrhoea score for grower and finisher pigs.**

Independent variable	GROWERS		FINISHERS	
	median	range	median	range
cough score <sup>†</sup>	0.21	0.00 - 1.14	0.28	0.00 - 0.87
sneeze score <sup>†</sup>	0.11	0.00 - 1.01	0.10	0.00 - 0.82
lesion score <sup>†</sup>	2.7	0.4 - 7.9	3.0	0.4 - 7.1
tail biting score <sup>†</sup>	0.00	0.00 - 0.28	0.0	0.0 - 0.8
pen cleanliness score <sup>†</sup>	2.0	1.0 - 4.2	2.0	1.0 - 5.0
pig cleanliness score <sup>†</sup>	9.8	3.0 - 19.7	12.2	6.2 - 21.1
diarrhoea score <sup>†</sup>	0.00	0.00 - 0.20	0.00	0.00 - 0.16

<sup>†</sup> For details on these measurements see section 3.2.2

**Table 3.3. The multiple regression models for the signs of injury and disease dependent variables for the grower pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area	2.740 3.020 -0.032 <sup>NS</sup>	1.75**	33.8
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity	-0.54 2.935 -0.033 <sup>NS</sup> 0.0596	1.59**	47.6
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity + Grower no. pigs per drinker	0.09 2.572 0.430 <sup>NS</sup> 0.0671 -0.0597	1.43***	59.2
Grower lesion score	Constant <sup>12</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity + Grower no. pigs per drinker + Grower slatted dunging area + Grower straw-bedded dunging area	0.43 1.950 0.999 <sup>NS</sup> 0.0615 -0.0588 0.585 <sup>NS</sup> -1.368	1.26***	71.2
ln Grower cough score	Constant <sup>3</sup> + Weaner slatted floor + Weaner straw-bedded floor	-0.776 -0.704 -0.823	0.674*	25.2
ln Grower sneeze score	Constant + Grower space allowance	-2.216 0.379	0.549*	19.0
ln Grower sneeze score	Constant + Grower space allowance + Number of sows	-2.700 0.438 0.001616	0.506**	34.1
ln Grower sneeze score	Constant + Grower space allowance + Number of sows + Grower length of trough/pig	-3.236 0.424 0.001592 11.06	0.462**	47.2
ln Grower scour score	Not significant			
ln Grower tailbiting score	Constant + Number of sows	-2.403 0.00127	0.393*	18.8
ln Grower tailbiting score	Constant + Number of sows + Grower lying area ammonia conc.	-2.504 0.00134 0.0259	0.354**	36.4
ln Grower tailbiting score	Constant + Number of sows + Grower lying area ammonia conc. + Grower length of trough/pig	-2.875 0.00134 0.0224 7.51	0.332**	46.6

<sup>1</sup> adjusted for grower concrete dunging area<sup>2</sup> adjusted for grower concrete lying area<sup>3</sup> adjusted for weaner kennel and outside slatted dunging area

\*, \*\*, \*\*\* indicate an F-probability of &lt;0.05, &lt;0.01 and &lt;0.001, respectively

<sup>NS</sup> non-significant i.e. T-probability > 0.05

**Table 3.4. The multiple regression models for the signs of injury and disease dependent variables for the finisher pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Finisher lesion score	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area	2.775 2.199 -0.815 <sup>NS</sup>	1.35***	49.1
Finisher lesion score	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area + Finisher no. of drinkers	1.845 1.974 -1.184 0.547	1.12***	66.7
ln Finisher cough score	Constant <sup>2</sup> + Finisher slatted dunging area + Finisher straw-bedded dunging area	-1.620 0.894 0.149 <sup>NS</sup>	0.523**	41.5
ln Finisher sneeze score	Constant <sup>3</sup> + Grower slatted lying area + Grower straw-bedded lying area	-1.710 0.788 -0.042 <sup>NS</sup>	0.502*	30.5
ln Finisher scour score	Constant + Finisher lying area ammonia conc.	-2.237 0.0444	0.237***	48.8
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough	-2.356 0.0466 0.0519	0.213***	60.3
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough + Weaner humidity	-2.867 0.0412 0.0595 0.00777	0.185***	71.4
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough + Weaner humidity + Weaner group size	-2.781 0.0404 0.0537 0.00912 -0.00528	0.157***	80.3
ln Finisher tailbiting score	Constant <sup>3</sup> + Grower slatted lying area + Grower straw-bedded lying area	-2.063 1.045 0.133 <sup>NS</sup>	0.686*	26.3

<sup>1</sup> adjusted for finisher concrete lying area<sup>2</sup> adjusted for finisher concrete dunging area<sup>3</sup> adjusted for grower concrete lying area

\*, \*\*, \*\*\* indicate an F-probability of &lt;0.05, &lt;0.01 and &lt;0.001, respectively

<sup>NS</sup> non-significant i.e. T-probability > 0.05

### 3.5 Discussion

There are few reports concerning the interaction of management and environmental factors and their effects on a range of clinical signs of disease of grower and finisher pigs in the UK. The results of this study have identified a number of factors within the rearing environment of the pig that account for a significant proportion of the variation in clinical signs of disease (lesion score, coughs, sneezes, diarrhoea and tail-biting) in pigs from a number of different commercial units.

#### *3.5.1 Lesion scores*

The provision of straw in either the lying or dunging area was associated with reduced lesions in both grower and finisher pigs compared with a slatted or concrete lying and dunging area. These findings agree with those of Veen et al (1985) who reported that piglets housed on slatted floors had higher injury scores than those housed with straw bedding. Hauck (1981) proposed that the majority of animal injuries in farm buildings were due to inadequate flooring. These injuries were due to trauma from sharp edges and inappropriate voids, lack of hoof wear or injuries due to slipping. The provision of straw bedding appears to be important in reducing injury indicated by the reduction of skin lesions in both grower and finisher pigs.

There are two main potential sources of injury to the pig; sharp or abrasive pen fixtures and fittings or other littermates. Injury from social interactions can occur through

aggressive behaviour, mounting behaviour or exploratory behaviour directed towards pen mates such as ear-biting, flank-biting or tail-biting. Piglets weaned onto straw have been reported to be more active than those weaned into accommodation without straw and spend 25% of their active periods performing straw directed behaviour (McKinnon *et al.*, 1989). Numerous studies have shown increased exploratory behaviour directed towards penmates (McKinnon, *et al.*, 1989; Putten and Dammers, 1976; Putten, 1980; Ekesbo, 1980; Schouten, 1986) in pigs housed without access to straw. Woodgush and Vestergaard (1991) suggest that the pig has an endogenous motivation for exploration and when housed in barren environmental conditions will redirect their investigation to inappropriate stimuli such as the ears and tails of littermates. Rushen (1993) argued that such behaviour is due to nutritional deficiencies (such as low fibre or protein) rather than inadequate housing. Straw may provide an additional source of nutrition (fibre) and/or a suitable substrate for exploratory behaviour reducing littermate exploratory behaviour and accompanying lesions. Environmental enrichment has also been shown to reduce aggressive episodes between pigs (Schaefer *et al.*, 1990; Simonsen, 1990; Petersen *et al.*, 1995), although there is evidence for and against straw reducing aggression. Kelley *et al.* (1980) found that provision of straw reduced aggression in restricted-fed pigs but did not inhibit the effects of overcrowding on increased aggression. Another study found no effect of straw on fighting between newly mixed growing pigs (Arey and Franklin, 1995). Broom (1991) suggested that the increased activity observed in weaners housed on straw, compared with those on full or part-slatted floors leaves the pigs less time for aggression, which may also be the case for the grower and finisher pigs in this study.

An increase in the humidity of the grower dunging area was associated with an increase in grower lesions. There are no current reports to indicate the optimal range of relative humidity for pigs kept indoors. However it is known that when the humidity is very high the pig will modify its behaviour by wallowing or lying on a wetted floor, as pigs become more dependent on water loss from the skin for thermoregulation (Close, 1981). This may result in increased aggression due to competition for 'cool' spots during humid conditions. It is possible that as the pigs spend increased time in dunging areas in humid conditions (McKinnon, *et al.*, 1989) they may come in contact with more sharp or abrasive fittings found in the dunging areas such as drinkers or slatted floors that can cause injury. According to Penny *et al.* (1981) heat-stressed pigs are more prone to developing abnormal behaviour patterns because they become more restless which may lead to heightened aggression and/or exploratory behaviour directed at pen-mates which may cause lesions or lead to increased aggression.

An increased number of pigs per drinker was associated with a reduction in grower lesion score. This is contrary to a previous study that found no effect of drinker allocation on skin lesion score (Turner *et al.*, 1999) but did find an increase in drinker-related aggression with an increasing number of pigs per drinker. It was expected that if any association were found to be present it would be that increased competition for drinkers would have increased lesion scores. It is possible that farms with environments with endemic aggression problems may have tried to remedy this situation by providing more drinkers to reduce competition and therefore aggression. However, it is more

likely that this variable may be an intermediate variable being related to certain housing systems and types of buildings not directly categorised in this study.

### 3.5.2 Coughs and sneezes

Increased prevalence of clinical signs of respiratory disease in the grower pigs was significantly associated with kennelled weaning accommodation with an external slatted dunging area. Coughing and sneezing increase when the receptors in the upper respiratory tract are more frequently activated by environmental stimuli such as allergens or dry cold air (Scheepens *et al.*, 1991). It may be possible that this housing system may be more prone to intermittent draughts, which has been previously demonstrated to promote respiratory disease (Scheepens *et al.*, 1991). Slatted floors also provide the least floor insulation and therefore may lead to some form of cold stress not found when insulative bedding is provided. It has previously been reported that inadequate cleaning of slatted floors may be associated with enteric disease (McOrist, 1997) and partially slatted floors may be associated with an increase in scour problems (Pearce, 1999). Slatted floors may be associated with increased residual faecal contamination without additional cleaning methods and therefore reduced hygiene may be a risk factor for the increased prevalence of coughs and sneezes. This is supported by the findings that both finisher cough and sneeze score were increased with the presence of a slatted lying area. Observation of the floor types found in this study showed that lying and dunging areas were less distinct than in concrete or straw-floored pens. This may have resulted in pigs on slatted floors having increased contact with faeces and therefore a greater risk of pathogenic infection.



The finding that increasing grower space allowance was associated with increased grower sneeze score is surprising as it is generally accepted that increased stocking density is a high risk factor for respiratory disease (Done, 1991). However, Stark *et al.* (1998) found that increased numbers of animals per room and increased number of animals per nursery pen were associated with reduced enzootic and pleuropneumonia respectively. It was concluded in this case that this was a statistical association with housing system but it is possible that the similar multivariate technique used in that study and the current study is revealing some form of association not shown in other studies not utilising the multivariate technique. Increased space allowance in these cases may be associated with a reduction in air temperature and a corresponding increase in cold stress, although ambient temperature was not found to be significantly associated with grower cough or sneeze score in the initial analysis and is unlikely during the season during and immediately preceding this study.

An increase in herd size was associated with an increase in grower sneeze score. This is in agreement with the results of a previous survey that used a general health score including diarrhoea, coughing and sneezing (Tuovinen *et al.*, 1997). Increasing herd size has commonly found to be an influential risk factor for respiratory diseases in swine (Stark, 2000). It was suggested that the reason for this large effect was due to its influence on disease dynamics (purchase policy, airborne infection, spread and maintenance within the herd) and management (large herds being managed differently from small herds).

### 3.5.3 Diarrhoea

Increased ammonia concentrations in the finisher pigs was associated with increased levels of scouring. Gaseous ammonia can have direct negative effects on the health of pigs and may also be indicative of inadequate ventilation, which may lead to other even more severe health risks such as increased airborne dust (Robertson, 1994). Exposure to 50ppm and 100ppm of ammonia reduces the systemic and local resistance to *Pasteurella multocida* infection in unweaned pigs kept in controlled conditions (Neumann *et al.*, 1987), although Robertson *et al.* (1990) suggest that ammonia can have detrimental effects at lower concentrations than these. It has also been demonstrated that pigs find the presence of ammonia aversive (Jones, 1996) showing a definite preference for fresh air in preference tests (Jones, 1996; Smith *et al.*, 1996). However, exposure to up to 100ppm of ammonia does not elicit any change in plasma cortisol concentration (Gustin *et al.*, 1994) so it is unlikely that this aversion is having an effect on the immune system through any form of hypothalamic-pituitary-adrenal activity that is usually associated with psychological stress. Six day exposure to 50 ppm ammonia increased pigs' pulmonary vascular response to endotoxins (Gustin *et al.*, 1994), although it is not known for definite whether more prolonged exposure to ammonia at lower concentrations, such as those observed in this study, would have a similar effect. A direct relationship between ammonia and scouring has not been identified in previous studies. However, the link between ammonia and respiratory disease is well-established (Robertson *et al.* 1990). There is also evidence for respiratory disease being a risk factor for diarrhoea (Tuovinen *et al.*, 1997) and this relationship may be being identified in this study.

The finding that increasing length of trough in the finishers is associated with increased scouring in this study is difficult to explain using a causal hypothesis. A larger trough may have been expected to reduce the occurrence of scouring due to reduced contact and therefore cross-infection or competition stress at feeding, although actual feeding space per pig was not found to be significant. Therefore this variable may be indicative of some housing type or other factor not directly categorised within this study.

Increased humidity within the weaner pens was associated with increased finisher scour. Again, it is unlikely that this is a direct effect due to the obvious changes in humidity from day to day in the UK's temperate climate. It is possible that this component of variation describes the local relative humidity along with some characteristic of the weaner housing not categorised in this study. Increased humidity was also associated with increased lesion score and may be a common environmental factor in reduced health and welfare in this study although this is in contrast with previous findings (Tuovinen *et al.*, 1997). A rise in humidity would increase the perceived temperature of the pig due to a reduction in evaporative cooling. This could result in increased wallowing behaviour (see above) with the associated faecal contact and greater risk of pathogenic infection and scours.

A reduction in finisher scouring being associated with larger weaner group size may be due to the beneficial effects, in terms of disease transfer, of the farmer being able to maintain stable groups of pigs, splitting down from an initial large group without re-mixing. Although the practice of re-mixing was categorised in this survey, this variable

may have been improved by determining what scale of re-mixing was actually taking place.

#### 3.5.4 Tail-biting

Herd size (number of sows) was positively associated with tail-biting in the grower pigs. As mentioned above, increased herd size can be associated with a number of accompanying factors that may cause a reduction in the health and welfare of pigs. Specifically, Blackshaw (1981) stated that an increase in herd size can result in the reduced inspection of livestock and therefore problems with tail-biting may be unnoticed for a longer period which may exacerbate the problem due to possible spread of the behaviour between pigs.

Ammonia and other noxious gases have been reported to increase the chances of tail-biting (Van Putten, 1969), which is supported by the current findings that increasing ammonia is associated with increased prevalence of tail-biting in grower pigs. As stated above (section 3.5.3), ammonia was related to increased prevalence of finisher scouring and is also suggested to be indicative of inadequate ventilation. This confirms previous reports of ammonia being a risk and probable causal factor in disease incidence and adds support to the suggestion by Robertson *et al.* (1990) that it can play a significant role in disease development at lower levels than previously indicated (In this study: grower ammonia concentration range = 0-32.9 ppm, finisher ammonia concentration range = 0-21 ppm). Pigs find ammonia concentrations of 10 ppm aversive compared to fresh un-ammoniated air (Jones *et al.*, 1996).

The finding that increasing length of trough per grower is associated with increased tail-biting of growers is also an unexpected association. It is possible that increased feeding space was associated with another factor such as type of feeding system or food type. Diet has been implicated as a major factor in mediating the onset of tail-biting in grower-finisher pigs (Arey, 1991) and it is possible that this component of variation is allied with some dietary variable not measured directly in this study.

Pigs reared under barren conditions can show increased exploratory behaviour towards novel objects (Pearce and Paterson, 1993) and pen-mates (McKinnon *et al.*, 1989; Wood-Gush and Vestergaard, 1991) and this may be irrespective of current housing (Olsson *et al.*, 1999). A slatted lying area has previously been shown to result in increased exploratory behaviour directed at pen-mates (McKinnon *et al.*, 1989) and has also been suggested to also be a barren environment for pigs in this study when considering exploratory behaviour (see section 2.5.2). Therefore, use of this floor type at the grower stage may result in the tail-biting behaviour observed in the finisher pigs of this study. Olsson *et al.* (1999) showed that rearing pigs under barren conditions could increase subsequent aggressive behaviour of pigs compared with those reared in a more enriched environment when both groups were kept under the same environmental conditions demonstrating the importance of early rearing conditions mentioned previously (section 2.5.2).

### 3.6 Conclusions

The results of this study indicates the factors within the environment of commercially reared grower-finisher pigs that are important in influencing health status and can be considered to be important for the pigs' well being. Those factors identified as increasing clinical signs of disease may be regarded as individual stressors, which the pig has to cope with in order to maintain its welfare. Evidence suggests that the effects of multiple concurrent environmental stressors may be considered to have a cumulative effect (Hyun *et al.*, 1998) and therefore each factor identified above may have a significant role in influencing pig health. Again, as in chapter two, floor-type has been identified as being important, particularly with straw as a positive factor and slatted floors as a negative factor. Factors relating to air quality such as ammonia and humidity have also been identified as being important giving support to current evidence of this area being significant in determining the welfare of pigs. Other associations are less clear in their effects on welfare and further research is required in these areas to understand the mechanisms involved. Knowledge of these factors will allow improvements to be made to the design of future husbandry systems designed to improve the health and welfare of growing pigs.

## **CHAPTER 3. INFLUENCE OF ENVIRONMENTAL CONDITIONS AND HUSBANDRY SYSTEM ON SIGNS OF INJURY AND DISEASE IN GROWER-FINISHER PIGS.**

### **3.1 Introduction**

Modern intensive systems designed to improve the economic viability of pig rearing can result in the increased spread of infection (Taylor, 1995). Increased herd sizes and close contact between animals favours a quick passage of pathogens, which may lead to an increase in virulence and an increased infection pressure (Hartung, 1994). The aetiology of disease in intensively housed livestock tends to be multifactorial, arising through an interaction of infection and environmental stress (Webster, 1982).

Common diseases of pigs include enzootic pneumonia, pleuropneumonia, atrophic rhinitis, porcine intestinal adenomatosis (PIA), *E. coli* enteritis and swine dysentery, all of which may result in a reduction in growth performance. For example infection with *Mycoplasma hyopneumoniae*, the organism causing enzootic pneumonia, has been shown to increase the rearing time from birth to 90 kg body weight by two weeks (Wallgren *et al.*, 1993) compared to pigs without infection. Enzootic pneumonia, pleuropneumonia and atrophic rhinitis are respiratory disorders and common clinical signs of infection are coughing and sneezing (Taylor, 1995). *E. coli* enteritis (mainly seen in the neo-natal pig), PIA and swine dysentery are the most common enteric diseases of pigs - enteric disease being the predominant cause of pig diarrhoea (Taylor, 1995).

The pig's resistance to pathogenic infection is regulated by its immune system which has been reported to be influenced by exposure to stressors (Johnson *et al.*, 1994; Wallgren *et al.*, 1994b). Unfavourable climatic conditions have been suggested to be a major source of health problems in pigs (Tielen, 1987). Heat (Machado-Neto *et al.*, 1987; Morrow-Tesch *et al.*, 1994), cold (Blecha and Kelley, 1981) and intermittent draughts (Scheepens *et al.*, 1991) have all been shown to alter the immune function of pigs. Particular husbandry techniques that have been shown to influence immune function including weaning (Blecha *et al.*, 1983; Blecha *et al.*, 1985; Bailey *et al.*, 1992; Wattrang *et al.*, 1998), transport (Dahlin *et al.*, 1993, McGlone *et al.*, 1993) and social regrouping (Wattrang *et al.*, 1994). A number of studies have reported that pigs of a higher social status have improved immune function (increased natural killer cell cytotoxicity) relative to those of lower ranking (McGlone *et al.*, 1993; Hessing *et al.*, 1994b Morrow-Tesch *et al.*, 1994) and that genetic variation also exists in the immune competence of pigs (Edfors-Lilja *et al.*, 1994).

Environmental factors such as overcrowding, diet, changes in humidity and temperature or a barren environment have also been related to behavioural problems such as tail-biting (reviewed by Arey, 1991) and physical injuries indicated by skin lesions. Skin lesion scoring was suggested by Ekesbo and demonstrated by De Koning (1984) to be a good measure of welfare as they indicate inadequate housing conditions resulting in physical trauma from sharp pen fittings and/or heightened aggressive behaviour. It is widely accepted that the health and welfare of an animal have a strong relationship.



Ewbank (1988) suggests that for practical purposes, there is merit in replacing the word “welfare” with the terms “health” and “well-being”. The welfare of diseased animals is poorer than that of non-diseased animals (Broom, 1988) and so signs of injury and disease can be considered to be good indicators for the assessment of welfare.

In order to continue with the measurement of the health and welfare of grower and finisher pigs kept under commercial conditions, this survey was designed to identify which husbandry and management procedures were important in mediating scores of clinical injury and disease in grower and finisher pigs reared under commercial conditions.

## 3.2 Methods and Materials

This study was carried out between 19/3/97 and 5/9/97 concurrently with the study reported in chapter two utilising the same 27 commercial units.

### *3.2.1 Husbandry and environmental factors*

These factors were recorded as stated in the materials and methods section of the previous chapter (sections 2.2.1. and 2.2.2)

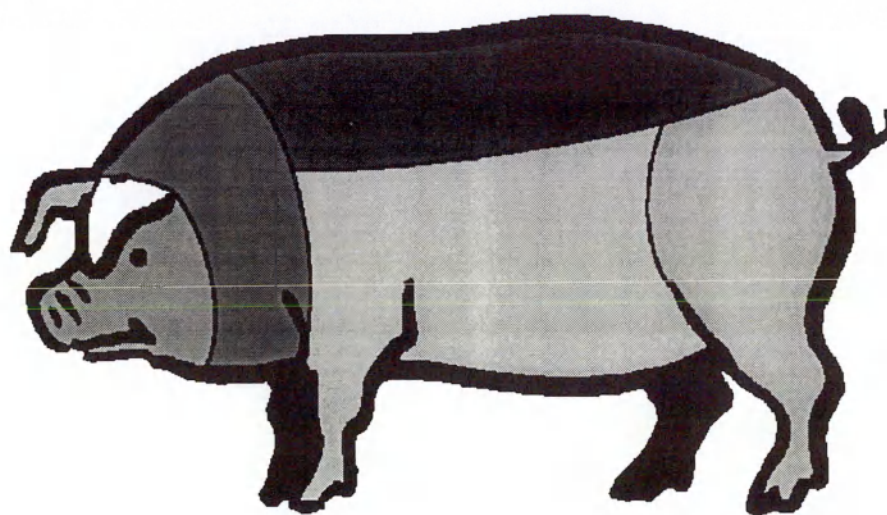
### *3.2.2 Welfare indicators*

#### *3.2.2.1 Coughs and Sneezes:*

An observer entered the pen and roused the pigs until they were all standing. For the following five-minute period a cough and sneeze score was determined. This was calculated by counting the number of coughs and sneezes in a pen and dividing it by the number of pigs. This was repeated for four grower and four finisher pens and a mean score per pig calculated for coughs and another for sneezes (the pens were chosen to be a representative sample of the house, i.e. away from entrances and from both sides and/or ends). Coughing is a good indicator for the presence of enzootic pneumonia in fattening pigs (Morris *et al.*, 1995).

### 3.2.2.2 Skin lesions and tail-biting:

Twenty-five pigs from 10 grower pens and 25 from 10 finisher pens were chosen at random from those that had not been mixed within the previous week. These were examined for skin lesions. A skin lesion was defined as a breakage in the skin. For the purpose of lesion scoring the skin of the pig was divided up into the following areas: face, left ear, right ear, neck (from point between ears to point on back level with front legs), back, left and right flank (sides of pig between front and back leg), left and right hind-quarter (back leg backwards). In each of these areas the presence or absence of lesions were recorded. The skin lesion score for each pig was calculated by determining the total number of areas containing a lesion. This is based on the method of scoring proposed by Ekesbo and used by De Koning (1984).



**Figure 3.1** A diagram to show how the surface area of the pig was divided in order to give skin lesion scores in the farm survey.

Each of the pigs were assessed for signs of tail-biting and given a score from 0-10 according to the system described in table 3.1. A score of 0 was recorded if there was no evidence of tail-biting, 1= 10% of tail damaged, 2= 20 % of tail damaged, etc. i.e. 10= tail completely absent.

**Table 3.1 The scoring system used to estimate tail biting damage in the farm survey.**

<b>Tail biting score</b>	<b>% tail damaged/missing</b>
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100

### 3.2.2.3 Diarrhoea:

Each of the pigs was examined for evidence of diarrhoea (peri-anal staining and/or presence of liquid faeces around anus) which was recorded as present or absent.

### 3.3 Statistical analysis

Cough, sneeze, scour and tail-biting scores were transformed according to the formula  $\ln(x+0.1)$  in order to fit approximate normal distribution patterns. Multiple regression models were constructed as in the previous chapter (section 2.3). All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

### 3.4 Results

The descriptive results for the independent variables recorded from the 27 farms in this study are presented in table 2.1. The median and range of values for the clinical signs of disease (cough score, sneeze score, lesion score, tail biting score, and diarrhoea) and pig/pen cleanliness for grower and finisher pigs are presented in table 3.2. The final multiple regression models for each of the grower and finisher signs of injury and disease are presented in tables 3.3 and 3.4.

**Table 3.2 The median and range of values for cough score, sneeze score, lesion score, tail biting score, pen cleanliness score, pig cleanliness score and diarrhoea score for grower and finisher pigs.**

Independent variable	GROWERS		FINISHERS	
	median	range	median	range
cough score <sup>†</sup>	0.21	0.00 - 1.14	0.28	0.00 - 0.87
sneeze score <sup>†</sup>	0.11	0.00 - 1.01	0.10	0.00 - 0.82
lesion score <sup>†</sup>	2.7	0.4 - 7.9	3.0	0.4 - 7.1
tail biting score <sup>†</sup>	0.00	0.00 - 0.28	0.0	0.0 - 0.8
pen cleanliness score <sup>†</sup>	2.0	1.0 - 4.2	2.0	1.0 - 5.0
pig cleanliness score <sup>†</sup>	9.8	3.0 - 19.7	12.2	6.2 - 21.1
diarrhoea score <sup>†</sup>	0.00	0.00 - 0.20	0.00	0.00 - 0.16

<sup>†</sup> For details on these measurements see section 3.2.2

**Table 3.3. The multiple regression models for the signs of injury and disease dependent variables for the grower pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area	2.740 3.020 -0.032 <sup>NS</sup>	1.75**	33.8
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity	-0.54 2.935 -0.033 <sup>NS</sup> 0.0596	1.59**	47.6
Grower lesion score	Constant <sup>1</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity + Grower no. pigs per drinker	0.09 2.572 0.430 <sup>NS</sup> 0.0671 -0.0597	1.43***	59.2
Grower lesion score	Constant <sup>12</sup> + Grower slatted lying area + Grower straw-bedded lying area + Grower dunging area humidity + Grower no. pigs per drinker + Grower slatted dunging area + Grower straw-bedded dunging area	0.43 1.950 0.999 <sup>NS</sup> 0.0615 -0.0588 0.585 <sup>NS</sup> -1.368	1.26***	71.2
In Grower cough score	Constant <sup>3</sup> + Weaner slatted floor + Weaner straw-bedded floor	-0.776 -0.704 -0.823	0.674*	25.2
In Grower sneeze score	Constant + Grower space allowance	-2.216 0.379	0.549*	19.0
In Grower sneeze score	Constant + Grower space allowance + Number of sows	-2.700 0.438 0.001616	0.506**	34.1
In Grower sneeze score	Constant + Grower space allowance + Number of sows + Grower length of trough/pig	-3.236 0.424 0.001592 11.06	0.462**	47.2
In Grower scour score	Not significant			
In Grower tailbiting score	Constant + Number of sows	-2.403 0.00127	0.393*	18.8
In Grower tailbiting score	Constant + Number of sows + Grower lying area ammonia conc.	-2.504 0.00134 0.0259	0.354**	36.4
In Grower tailbiting score	Constant + Number of sows + Grower lying area ammonia conc. + Grower length of trough/pig	-2.875 0.00134 0.0224 7.51	0.332**	46.6

<sup>1</sup> adjusted for grower concrete dunging area<sup>2</sup> adjusted for grower concrete lying area<sup>3</sup> adjusted for weaner kennel and outside slatted dunging area

\*, \*\*, \*\*\* indicate an F-probability of &lt;0.05, &lt;0.01 and &lt;0.001, respectively

<sup>NS</sup> non-significant i.e. T-probability > 0.05

**Table 3.4. The multiple regression models for the signs of injury and disease dependent variables for the finisher pigs.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Finisher lesion score	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area	2.775 2.199 -0.815 <sup>NS</sup>	1.35***	49.1
Finisher lesion score	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area + Finisher no. of drinkers	1.845 1.974 -1.184 0.547	1.12***	66.7
ln Finisher cough score	Constant <sup>2</sup> + Finisher slatted dunging area + Finisher straw-bedded dunging area	-1.620 0.894 0.149 <sup>NS</sup>	0.523**	41.5
ln Finisher sneeze score	Constant <sup>3</sup> + Grower slatted lying area + Grower straw-bedded lying area	-1.710 0.788 -0.042 <sup>NS</sup>	0.502*	30.5
ln Finisher scour score	Constant + Finisher lying area ammonia conc.	-2.237 0.0444	0.237***	48.8
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough	-2.356 0.0466 0.0519	0.213***	60.3
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough + Weaner humidity	-2.867 0.0412 0.0595 0.00777	0.185***	71.4
ln Finisher scour score	Constant + Finisher lying area ammonia conc. + Finisher length of trough + Weaner humidity + Weaner group size	-2.781 0.0404 0.0537 0.00912 -0.00528	0.157***	80.3
ln Finisher tailbiting score	Constant <sup>3</sup> + Grower slatted lying area + Grower straw-bedded lying area	-2.063 1.045 0.133 <sup>NS</sup>	0.686*	26.3

<sup>1</sup> adjusted for finisher concrete lying area<sup>2</sup> adjusted for finisher concrete dunging area<sup>3</sup> adjusted for grower concrete lying area

\*, \*\*, \*\*\* indicate an F-probability of &lt;0.05, &lt;0.01 and &lt;0.001, respectively

<sup>NS</sup> non-significant i.e. T-probability > 0.05



### 3.5 Discussion

There are few reports concerning the interaction of management and environmental factors and their effects on a range of clinical signs of disease of grower and finisher pigs in the UK. The results of this study have identified a number of factors within the rearing environment of the pig that account for a significant proportion of the variation in clinical signs of disease (lesion score, coughs, sneezes, diarrhoea and tail-biting) in pigs from a number of different commercial units.

#### *3.5.1 Lesion scores*

The provision of straw in either the lying or dunging area was associated with reduced lesions in both grower and finisher pigs compared with a slatted or concrete lying and dunging area. These findings agree with those of Veen et al (1985) who reported that piglets housed on slatted floors had higher injury scores than those housed with straw bedding. Hauck (1981) proposed that the majority of animal injuries in farm buildings were due to inadequate flooring. These injuries were due to trauma from sharp edges and inappropriate voids, lack of hoof wear or injuries due to slipping. The provision of straw bedding appears to be important in reducing injury indicated by the reduction of skin lesions in both grower and finisher pigs.

There are two main potential sources of injury to the pig; sharp or abrasive pen fixtures and fittings or other littermates. Injury from social interactions can occur through

aggressive behaviour, mounting behaviour or exploratory behaviour directed towards pen mates such as ear-biting, flank-biting or tail-biting. Piglets weaned onto straw have been reported to be more active than those weaned into accommodation without straw and spend 25% of their active periods performing straw directed behaviour (McKinnon *et al.*, 1989). Numerous studies have shown increased exploratory behaviour directed towards penmates (McKinnon, *et al.*, 1989; Putten and Dammers, 1976; Putten, 1980; Ekesbo, 1980; Schouten, 1986) in pigs housed without access to straw. Woodgush and Vestergaard (1991) suggest that the pig has an endogenous motivation for exploration and when housed in barren environmental conditions will redirect their investigation to inappropriate stimuli such as the ears and tails of littermates. Rushen (1993) argued that such behaviour is due to nutritional deficiencies (such as low fibre or protein) rather than inadequate housing. Straw may provide an additional source of nutrition (fibre) and/or a suitable substrate for exploratory behaviour reducing littermate exploratory behaviour and accompanying lesions. Environmental enrichment has also been shown to reduce aggressive episodes between pigs (Schaefer *et al.*, 1990; Simonsen, 1990; Petersen *et al.*, 1995), although there is evidence for and against straw reducing aggression. Kelley *et al.* (1980) found that provision of straw reduced aggression in restricted-fed pigs but did not inhibit the effects of overcrowding on increased aggression. Another study found no effect of straw on fighting between newly mixed growing pigs (Arey and Franklin, 1995). Broom (1991) suggested that the increased activity observed in weaners housed on straw, compared with those on full or part-slatted floors leaves the pigs less time for aggression, which may also be the case for the grower and finisher pigs in this study.

An increase in the humidity of the grower dunging area was associated with an increase in grower lesions. There are no current reports to indicate the optimal range of relative humidity for pigs kept indoors. However it is known that when the humidity is very high the pig will modify its behaviour by wallowing or lying on a wetted floor, as pigs become more dependent on water loss from the skin for thermoregulation (Close, 1981). This may result in increased aggression due to competition for 'cool' spots during humid conditions. It is possible that as the pigs spend increased time in dunging areas in humid conditions (McKinnon, *et al.*, 1989) they may come in contact with more sharp or abrasive fittings found in the dunging areas such as drinkers or slatted floors that can cause injury. According to Penny *et al.* (1981) heat-stressed pigs are more prone to developing abnormal behaviour patterns because they become more restless which may lead to heightened aggression and/or exploratory behaviour directed at pen-mates which may cause lesions or lead to increased aggression.

An increased number of pigs per drinker was associated with a reduction in grower lesion score. This is contrary to a previous study that found no effect of drinker allocation on skin lesion score (Turner *et al.*, 1999) but did find an increase in drinker-related aggression with an increasing number of pigs per drinker. It was expected that if any association were found to be present it would be that increased competition for drinkers would have increased lesion scores. It is possible that farms with environments with endemic aggression problems may have tried to remedy this situation by providing more drinkers to reduce competition and therefore aggression. However, it is more

likely that this variable may be an intermediate variable being related to certain housing systems and types of buildings not directly categorised in this study.

### 3.5.2 Coughs and sneezes

Increased prevalence of clinical signs of respiratory disease in the grower pigs was significantly associated with kennelled weaning accommodation with an external slatted dunging area. Coughing and sneezing increase when the receptors in the upper respiratory tract are more frequently activated by environmental stimuli such as allergens or dry cold air (Scheepens *et al.*, 1991). It may be possible that this housing system may be more prone to intermittent draughts, which has been previously demonstrated to promote respiratory disease (Scheepens *et al.*, 1991). Slatted floors also provide the least floor insulation and therefore may lead to some form of cold stress not found when insulative bedding is provided. It has previously been reported that inadequate cleaning of slatted floors may be associated with enteric disease (McOrist, 1997) and partially slatted floors may be associated with an increase in scour problems (Pearce, 1999). Slatted floors may be associated with increased residual faecal contamination without additional cleaning methods and therefore reduced hygiene may be a risk factor for the increased prevalence of coughs and sneezes. This is supported by the findings that both finisher cough and sneeze score were increased with the presence of a slatted lying area. Observation of the floor types found in this study showed that lying and dunging areas were less distinct than in concrete or straw-floored pens. This may have resulted in pigs on slatted floors having increased contact with faeces and therefore a greater risk of pathogenic infection.

The finding that increasing grower space allowance was associated with increased grower sneeze score is surprising as it is generally accepted that increased stocking density is a high risk factor for respiratory disease (Done, 1991). However, Stark *et al.* (1998) found that increased numbers of animals per room and increased number of animals per nursery pen were associated with reduced enzootic and pleuropneumonia respectively. It was concluded in this case that this was a statistical association with housing system but it is possible that the similar multivariate technique used in that study and the current study is revealing some form of association not shown in other studies not utilising the multivariate technique. Increased space allowance in these cases may be associated with a reduction in air temperature and a corresponding increase in cold stress, although ambient temperature was not found to be significantly associated with grower cough or sneeze score in the initial analysis and is unlikely during the season during and immediately preceding this study.

An increase in herd size was associated with an increase in grower sneeze score. This is in agreement with the results of a previous survey that used a general health score including diarrhoea, coughing and sneezing (Tuovinen *et al.*, 1997). Increasing herd size has commonly found to be an influential risk factor for respiratory diseases in swine (Stark, 2000). It was suggested that the reason for this large effect was due to its influence on disease dynamics (purchase policy, airborne infection, spread and maintenance within the herd) and management (large herds being managed differently from small herds).

### 3.5.3 Diarrhoea

Increased ammonia concentrations in the finisher pigs was associated with increased levels of scouring. Gaseous ammonia can have direct negative effects on the health of pigs and may also be indicative of inadequate ventilation, which may lead to other even more severe health risks such as increased airborne dust (Robertson, 1994). Exposure to 50ppm and 100ppm of ammonia reduces the systemic and local resistance to *Pasteurella multocida* infection in unweaned pigs kept in controlled conditions (Neumann *et al.*, 1987), although Robertson *et al.* (1990) suggest that ammonia can have detrimental effects at lower concentrations than these. It has also been demonstrated that pigs find the presence of ammonia aversive (Jones, 1996) showing a definite preference for fresh air in preference tests (Jones, 1996; Smith *et al.*, 1996). However, exposure to up to 100ppm of ammonia does not elicit any change in plasma cortisol concentration (Gustin *et al.*, 1994) so it is unlikely that this aversion is having an effect on the immune system through any form of hypothalamic-pituitary-adrenal activity that is usually associated with psychological stress. Six day exposure to 50 ppm ammonia increased pigs' pulmonary vascular response to endotoxins (Gustin *et al.*, 1994), although it is not known for definite whether more prolonged exposure to ammonia at lower concentrations, such as those observed in this study, would have a similar effect. A direct relationship between ammonia and scouring has not been identified in previous studies. However, the link between ammonia and respiratory disease is well-established (Robertson *et al.* 1990). There is also evidence for respiratory disease being a risk factor for diarrhoea (Tuovinen *et al.*, 1997) and this relationship may be being identified in this study.

The finding that increasing length of trough in the finishers is associated with increased scouring in this study is difficult to explain using a causal hypothesis. A larger trough may have been expected to reduce the occurrence of scouring due to reduced contact and therefore cross-infection or competition stress at feeding, although actual feeding space per pig was not found to be significant. Therefore this variable may be indicative of some housing type or other factor not directly categorised within this study.

Increased humidity within the weaner pens was associated with increased finisher scour. Again, it is unlikely that this is a direct effect due to the obvious changes in humidity from day to day in the UK's temperate climate. It is possible that this component of variation describes the local relative humidity along with some characteristic of the weaner housing not categorised in this study. Increased humidity was also associated with increased lesion score and may be a common environmental factor in reduced health and welfare in this study although this is in contrast with previous findings (Tuovinen *et al.*, 1997). A rise in humidity would increase the perceived temperature of the pig due to a reduction in evaporative cooling. This could result in increased wallowing behaviour (see above) with the associated faecal contact and greater risk of pathogenic infection and scours.

A reduction in finisher scouring being associated with larger weaner group size may be due to the beneficial effects, in terms of disease transfer, of the farmer being able to maintain stable groups of pigs, splitting down from an initial large group without re-mixing. Although the practice of re-mixing was categorised in this survey, this variable

may have been improved by determining what scale of re-mixing was actually taking place.

#### 3.5.4 Tail-biting

Herd size (number of sows) was positively associated with tail-biting in the grower pigs. As mentioned above, increased herd size can be associated with a number of accompanying factors that may cause a reduction in the health and welfare of pigs. Specifically, Blackshaw (1981) stated that an increase in herd size can result in the reduced inspection of livestock and therefore problems with tail-biting may be unnoticed for a longer period which may exacerbate the problem due to possible spread of the behaviour between pigs.

Ammonia and other noxious gases have been reported to increase the chances of tail-biting (Van Putten, 1969), which is supported by the current findings that increasing ammonia is associated with increased prevalence of tail-biting in grower pigs. As stated above (section 3.5.3), ammonia was related to increased prevalence of finisher scouring and is also suggested to be indicative of inadequate ventilation. This confirms previous reports of ammonia being a risk and probable causal factor in disease incidence and adds support to the suggestion by Robertson *et al.* (1990) that it can play a significant role in disease development at lower levels than previously indicated (In this study: grower ammonia concentration range = 0-32.9 ppm, finisher ammonia concentration range = 0-21 ppm). Pigs find ammonia concentrations of 10 ppm aversive compared to fresh un-ammoniated air (Jones *et al.*, 1996).



The finding that increasing length of trough per grower is associated with increased tail-biting of growers is also an unexpected association. It is possible that increased feeding space was associated with another factor such as type of feeding system or food type. Diet has been implicated as a major factor in mediating the onset of tail-biting in grower-finisher pigs (Arey, 1991) and it is possible that this component of variation is allied with some dietary variable not measured directly in this study.

Pigs reared under barren conditions can show increased exploratory behaviour towards novel objects (Pearce and Paterson, 1993) and pen-mates (McKinnon *et al.*, 1989; Wood-Gush and Vestergaard, 1991) and this may be irrespective of current housing (Olsson *et al.*, 1999). A slatted lying area has previously been shown to result in increased exploratory behaviour directed at pen-mates (McKinnon *et al.*, 1989) and has also been suggested to also be a barren environment for pigs in this study when considering exploratory behaviour (see section 2.5.2). Therefore, use of this floor type at the grower stage may result in the tail-biting behaviour observed in the finisher pigs of this study. Olsson *et al.* (1999) showed that rearing pigs under barren conditions could increase subsequent aggressive behaviour of pigs compared with those reared in a more enriched environment when both groups were kept under the same environmental conditions demonstrating the importance of early rearing conditions mentioned previously (section 2.5.2).

### 3.6 Conclusions

The results of this study indicates the factors within the environment of commercially reared grower-finisher pigs that are important in influencing health status and can be considered to be important for the pigs' well being. Those factors identified as increasing clinical signs of disease may be regarded as individual stressors, which the pig has to cope with in order to maintain its welfare. Evidence suggests that the effects of multiple concurrent environmental stressors may be considered to have a cumulative effect (Hyun *et al.*, 1998) and therefore each factor identified above may have a significant role in influencing pig health. Again, as in chapter two, floor-type has been identified as being important, particularly with straw as a positive factor and slatted floors as a negative factor. Factors relating to air quality such as ammonia and humidity have also been identified as being important giving support to current evidence of this area being significant in determining the welfare of pigs. Other associations are less clear in their effects on welfare and further research is required in these areas to understand the mechanisms involved. Knowledge of these factors will allow improvements to be made to the design of future husbandry systems designed to improve the health and welfare of growing pigs.

## CHAPTER 4. INFLUENCE OF HUSBANDRY SYSTEM, TRANSPORT AND LAIRAGE ENVIRONMENT ON BEHAVIOUR IN LAIRAGE.

### 4.1 Introduction

The behaviour of pigs at unloading and in lairage is a potential indicator of their current welfare as it reflects the ability of a pig to cope with number of different stressors including transport, a novel environment, regrouping and human interaction. It is well known that the difficulty of handling pigs is dependent on aspects of their rearing environment (e.g., Grandin *et al.*, 1987; Grandin 1993; Abbott *et al.*, 1997; Hunter *et al.*, 1997; Geverink *et al.*, 1999) and reducing handling difficulties may improve the welfare of pigs and that of lairage staff. Important factors that have previously been identified as improving the ease of handling in pigs include natural lighting during rearing (Hunter *et al.*, 1997), previous moving experience (Hunter *et al.*, 1994; Abbott *et al.*, 1997; Hunter *et al.*, 1997 Geverink *et al.*, 1998c), genetics (Grandin, 1993), a barren rearing environment (Grandin, 1993; Hunter *et al.*, 1997; Geverink *et al.*, 1999) and reduced human contact (Grandin *et al.*, 1987).

Pigs are usually regrouped at lairage in large pens for ease of management. This can potentially lead to increased aggression due to the establishment of a new social hierarchy (Barnett *et al.*, 1993). Aggression in pigs is a serious welfare concern for the pig industry (Erhard and Mendl, 1997). Factors known to mediate aggression in pigs include pen design (McGlone and Curtis, 1985; Barnett *et al.*, 1993), group composition (Blackshaw *et al.*, 1987), crowding (Kelley *et al.*, 1980) and rearing conditions

(Schouten, 1986). However, little is known about the effects of the rearing environment on levels of aggression in lairage.

In order to make recommendations for future husbandry practices designed to improve the welfare of pigs at slaughter, it is important to determine what factors within the rearing environment are associated with the ability of pigs to cope with the stressors. This study was designed to measure ease of handling and levels of aggressive behaviour in lairage and to determine aspects of the rearing environment that influence the variation in behaviour.

## **4.2 Materials and methods**

This study took place between June and October of 1998 involving 20 out of the 27 farms utilised in the previous study (see chapters two and three) and that were used in the studies described in chapters five and six. Details of management factors such as herd size, breed type, housing, feeding and manure disposal systems; physical environment features such as use of bedding, ventilation type, ambient temperatures and pen size; and social environment features such as group size, stocking density and number of mixes of social groups were recorded by personal interview and farm visits (descriptive statistics shown in tables 4.1 and 4.2). In addition, details of transportation to the slaughter house such as time of last feed, distance travelled, duration of the journey, weather conditions and vehicle design and layout; and of lairage conditions such as duration, pen size, stocking density and temperature were also recorded.

This study took place in 3 abattoirs involving the same deliveries of pigs used in the following bursitis and gastric ulcer studies (see chapters 5 & 6).

#### 4.2.1 Lorry unloading time

Time to unload was assessed by determining the time taken from the entrance of the driver/lairage staff until the last pig had left each lorry deck based on methodology used by Abbott *et al.*, 1997. The total time taken to unload each deck of the transporter was divided by the number of pigs on that deck in order to give an average unloading time per animal.

#### 4.2.2 Handling score

The pigs were observed at the base of the unloading ramp and details of the interaction between the lorry driver and each animal noted. Each pig in a delivery was given a subjective behaviour score based on the method of Lawrence *et al.* (1991) as shown in table 4.1.

**Table 4.1 Scoring method used in classifying the behaviour of the pigs at unloading at lairage.**

Score	Definition
1	Walked or ran down corridor voluntarily.
2	Walked easily, only hesitating to show interest.
3	Hesitated but recommenced movement without human contact.
4	Stopped, but showed no physical resistance to movement on human contact.
5	Stopped, offered physical resistance to movement on human contact.

The average unloading times and the average of these handling scores determined individual farm scores, which were used in the construction of the multiple regression models below.

#### *4.2.3 Agonistic behaviour in lairage*

The pigs were observed for 30 minutes in the lairage pen starting when the lairage pen gate was closed and the time and duration of all agonistic interactions noted. A fight was considered to have begun/ finished based on criteria as used by Moore *et al.* (1994). Briefly, fights were recorded as beginning when open mouth contact occurred and concluding when the pigs had not performed an aggressive act (biting, pushing, mounting, pressing, etc.) for 5 seconds. A score was given based on the number of fights in 30 minutes and the average duration of fights was determined.

#### *4.2.4 Skin lesions*

Skin lesions were assessed for 25 pigs randomly chosen from the delivery according to the method described in 3.2.2.2. Existing skin lesions prior to transport and lairage were not measured for logistical reasons. However, this did not prevent differences in skin damage due to lairage conditions being found in a previous study (Geverink *et al.*, 1996).

### 4.3 Statistical analysis

A farm score was calculated for the delivery from each farm for handling score, average unloading time per pig, number of fights and average skin lesion score. These farm scores were used in the construction of a multiple regression model for each dependent variable as in section 2.3. The correlation coefficients between all behavioural scores and skin lesion score was calculated. All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

## 4.4 Results

The descriptive statistics for the 16 farms in this study are shown in tables 4.2 and 4.3. The mean handling score, average unload time per pig, number of fights in lairage pen and the prevalence of skin lesions for each farm are shown in table 4.4. Correlations between the dependent variables are shown in table 4.5 and the results of the multiple regression modelling are shown in table 4.6.

**Table 4.2 The descriptive results for the continuous independent variables recorded from the 16 farms in this study.**

Independent variable	Median	Range
No. of sows	181	15 – 400
No. Growers & Finishers	1382.5	180 – 4000
Weaning age (weeks)	3.75	3 – 5
Weaning weight (kg)	8.0	7.0 – 12.0
Weaner group size	22	15 – 100
Grower group size	26	14 – 90
Grower pen size (m <sup>2</sup> )	8.5	6.0 – 39.7
Grower space allowance	0.42	0.26 – 0.68
Grower trough space (m/pig)	1.45	0.50 – 2.90
Grower pen temperature (°c)	20	20 – 21
Finisher group size	19	8 – 80
Finisher pen size (m <sup>2</sup> )	11.7	5.1 – 54.0
Finisher space allowance (m <sup>2</sup> /pig)	0.670	0.443 – 0.954
Finisher trough space (m/pig)	1.35	0.200 – 9.00
Finisher pen temperature (°c)	17	15 – 17
Abattoir space allowance (m <sup>2</sup> /pig)	0.515	0.253 – 1.100
Abattoir duration (min)	65	20 – 120
Duration of journey (min)	78	30 – 210
Journey distance (miles)	44.19	15 – 100
Number of pigs on the lorry	56	20 - 162
Number of pigs in lairage pen	56	20 - 120
Lorry space allowance (m <sup>2</sup> /pig)	0.403	0.317 – 0.574



**Table 4.3 The descriptive results for the discrete independent variables recorded from the 16 farms in this study.**

	Number of Farms With	Number of Farms Without
Mixing at Weaning	81	19
Mixing at Grower Stage	19	81
Mixing at Finisher Stage	19	81
Pelleted Finisher diet	44	56
Straw bedding for Growers	31	69
Straw bedding for Finishers	25	75

**Table 4.4 Mean handling score, average unload time per pig, number of fights in lairage pen and the prevalence of skin lesions for each farm.**

Farm	Handling score	Unload time (s)	Number of fights	Skin lesion score
a	2.7	2.4	5	2.0
b	2.1	2.3	47	3.2
c	1.5	1.8	12	2.6
d	1.1	2.3	12	6.7
e	3.2	3.4	3	2.8
f	1.6	1.8	40	6.4
g	1.9	4.3	14	3.2
h	2.3	3.1	41	6.1
i	2.2	1.7	41	6.8
j	2.3	2.6	6	4.9
k	2.8	6.5	20	4.5
l	2.5	2.8	6	5.0
m	1.7	2.3	8	3.2
n	1.7	2.5	38	6.4
o	2.3	3.0	13	7.0
p	1.4	1.9	21	5.0
Average	2.1	2.8	20.4	4.7
SEM	0.14	0.30	3.87	0.43

**Table 4.5 Correlation coefficients for mean handling score, average unload time per pig, number of fights in lairage pen and the prevalence of skin lesions.**

	Handling score	Unload time	Number of fights	Skin lesion score
Handling score	1			
Unload time	0.52	1		
Number of fights	-0.23	-0.18	1	
Skin lesion score	-0.30	-0.13	0.44	1

**Table 4.6 The multiple regression models for mean handling score, average unload time per pig, number of fights in lairage pen and the prevalence of skin lesions.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Abattoir handling score	Constant <sup>1</sup> + Grower no. of drinkers	2.700 -0.2456	0.455**	43.0
Abattoir handling score	Constant <sup>1</sup> + Grower no. of drinkers + Finisher slatted lying area + Finisher straw-bedded lying area	2.475 -0.2959 0.565 0.740	0.320***	76.2
Abattoir handling score	Constant <sup>1</sup> + Grower no. of drinkers + Finisher slatted lying area + Finisher straw-bedded lying area + Grower space allowance	3.365 -0.2993 0.538 0.402 <sup>NS</sup> -1.821	0.265***	85.2
√ Unload time	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area	1.4797 0.073 <sup>NS</sup> 0.574	0.209**	61.9
√ Unload time	Constant <sup>1</sup> + Finisher slatted lying area + Finisher straw-bedded lying area + A. pleuropneumoniae vaccine	1.4397 0.113 <sup>NS</sup> 0.534 0.320	0.183***	73.0
In Abattoir agonistic score	Constant + Finisher space allowance	5.591 -4.292	0.588***	57.4
In Abattoir lesion score	Constant <sup>2</sup> + Grower slatted lying area + Grower straw-bedded lying area	1.695 -0.050 <sup>NS</sup> -0.737	0.267**	61.7
In Abattoir lesion score	Constant <sup>2</sup> + Grower slatted lying area + Grower straw-bedded lying area + Finishers thermostatically controlled	1.695 -0.250 <sup>NS</sup> -0.737 0.399	0.225	74.9
In Abattoir lesion score	Constant <sup>2</sup> + Grower slatted lying area + Grower straw-bedded lying area + Finishers thermostatically controlled + Finisher space allowance	2.161 -0.208 <sup>NS</sup> -0.587 0.478 -0.808	0.199***	75.5

<sup>1</sup> adjusted for finisher concrete lying area<sup>2</sup> adjusted for grower concrete lying area<sup>NS</sup> Non-significant i.e. T-probability > 0.05

\*, \*\*, \*\*\* indicate an F-probability of &lt;0.05, &lt;0.01 and &lt;0.001, respectively

## 4.5 Discussion

This study has identified a number of significant management and environmental factors that mediate the variation in the behaviour of pigs at unloading and in lairage from a number of different commercial units.

### 4.5.1 Lorry unloading time

In this study the increase in the difficulty of handling was positively correlated with average unloading time (see table 6.2). However, an increase in unloading time was associated with the provision of straw bedding not, as for the actual handling score, with a slatted lying floor in the finisher pen. This supports the findings of those previous studies reporting that pigs from enriched environments are more difficult to move (Grandin, 1993; Hunter *et al.*, 1997; Geversink *et al.*, 1999). In the farm survey of human approach behaviour finishers reared with straw bedding appeared to be less fearful of humans showing increased human approach behaviour compared to those reared under more barren conditions, but were also observed to be less excitable (see section 2.5.2). This apparent difference in response to humans may be due to an increased motivation to explore the environment outside the home pen in pigs from barren rather than enriched environments, supporting an earlier suggestion by Geversink *et al.* (1999) who found similar results.

The association between vaccination against *Actinobacillus pleuropneumoniae* with reduced unload time is unlikely to be a causal relationship. The use of the vaccine

implies that there is, or has been, a respiratory health problem within the herd as its use carries a fixed cost and is unlikely to be carried out unnecessarily. There are a large number of risk factors for an increased prevalence of pleuropneumonia in growing pigs (Stark, 2000), the variation of which may be predicted when considering the use of this vaccine as a component factor in this model. However, it is difficult to pinpoint which factors may also be important in mediating variation in unloading time.

#### *4.5.2 Handling score*

The first identified factor in the handling score model from the current study is that an increased number of drinkers found in the grower pen is associated with pigs that are easier to handle, an association that has not been previously reported. There is a lack of information as to the importance of drinker provision on the behaviour of growing pigs. However, it was suggested in chapter 3 (section 3.5.1) that an increase in the number of drinkers could represent a farmer's attempts to improve poor environmental conditions. Pigs from environments that could be considered suboptimal (barren conditions, lack of natural daylight and lack of human contact) have been demonstrated to be easier to handle (see section 6.1). It is also stated in section 3.5.1 that it is more likely that number of drinkers is associated with other environmental variables or clusters of variables not categorised in this survey. Number of drinkers in the grower pen is the first term in a model that accounts for 73 per cent of the variation in handling scores of the pigs in this study and is therefore still an important predictor for this measure of welfare. This finding also emphasises the importance of previous rearing conditions in determining current behaviour patterns as discussed in chapter two.

Rearing with a slatted dunging area was associated with pigs that were more difficult to handle. This appears to be contrary to those previous studies listed above that found that pigs reared in a barren environment were easier to handle. General observation of the pigs at unloading showed that those from non-straw systems were more excitable and these animals frequently made contact with the haulier who was unloading them and often stopped to explore fixtures and fittings of the loading ramp and lairage holding area. This resulted in increased human contact in order to drive the animals and therefore an increased handling score according to the scoring system used for this study. This increased “excitability” in pigs from barren environments has been reported in previous studies (Grandin, 1990; Pearce and Paterson, 1993). Excitable pigs have also been demonstrated to show greater interest in novel objects outside the home pen, although they appear to also find novelty more aversive (Lawrence *et al.*, 1991).

In a previous study, pigs kept at lower stocking densities showed increased general exploratory behaviour in the home pen (Pearce and Paterson, 1993). This apparent increase in exploratory motivation may explain why an increase in grower space allowance was associated with an improved handling score as pigs from higher space allowances may have voluntarily moved more quickly to explore the novel environment.

#### *4.5.3 Number of agonistic interactions*

All pigs in the current study were subjected to mixing during transport and in lairage and all groups showed some level of agonistic behaviour. As pigs do not fight during

transport (Lambooy, 1988), the establishment of a social dominance order therefore took place in the lairage pen. The current findings show that an increase in finisher space allowance can predict a decrease in aggressive behaviour in lairage. Space allowance has an important role in determining the level and quality of agonistic behaviour in pigs. An increased space allowance allows pigs to withdraw from aggressive pen mates and remove themselves from visual contact from others, important in the resolving of agonistic encounters (McGlone and Curtis, 1985). A reduced space allowance can result in fights being interrupted, which can perpetuate agonistic interactions (Baxter, 1985), whilst increased space allowance is important in the development of normal social behaviour in growing pigs (Schouten, 1986). A previous study found that fighting in pigs mixed in lairage could be predicted by the level of aggressive behaviour shown in the home pen (Geverink *et al.*, 1998a). It is likely that the reduced aggression in lairage in pigs from farms with increased space allowance is due to the expected reduction of aggressive behaviour on the units with lower stocking densities for finisher pigs. De Jong *et al.* (2000) found that rearing in an enriched environment could reduce aggression in pigs in lairage. However, this study may have confounded environmental enrichment with the increased space allowance of the finisher pigs before transport. Other factors that have been found to be associated with agonistic behaviour in lairage include duration of previous food deprivation (Brown *et al.*, 1999) and temperature (Fraquenza *et al.*, 1998). Neither of these factors were found to be significant, although the maximal conditions for these two factors in this study did not equal those from these previous experiments (18 hours food deprivation (Brown *et al.*, 1999) and a mean temperature of 35°C (Fraquenza *et al.*, 1998) – compared with 13 hours food deprivation and 24°C, in the current study). Mixing and driving are also known to have important effects on agonistic behaviour and skin damage (Geverink *et*

*al.*, 1998a), but as all pigs were subjected to the same handling procedure, differentiation based on rearing conditions would not have revealed these two factors.

#### 4.5.4 Skin lesion score in lairage

Skin lesion scoring is considered to be a good measure of welfare (De Koning, 1984) as it indicates inadequate environmental conditions resulting in physical trauma from sharp pen fittings and/or heightened aggressive behaviour. As lairage conditions were not significantly altered between groups, differences in lesion score were due to variation in the number and intensity of fights and may give more accurate measure of the effects of fighting than determining the number of fights. The provision of straw bedding during the grower rearing period was associated with reduced skin lesions being observed in the lairage pen. The provision of straw bedding during rearing may enrich the environment which has been reported as reducing aggressive behaviour (Schaefer *et al.*, 1990; Simonsen, 1990; Petersen *et al.*, 1995), although there is conflicting evidence in this area (see section 3.5.1). All the fully environmentally controlled buildings associated with increased skin lesion score were what may be considered barren, with fully slatted floors and low levels of natural light. These current results provide evidence that environmental enrichment during rearing reduces subsequent aggressive behaviour in lairage and also demonstrates that it is also important in reducing skin damage due to fighting in lairage. The finding that finisher space allowance is also important in reducing skin lesion score is expected considering the relationship between space allowance and agonistic behaviour discussed above.

## 4.6 Conclusions

The behaviour of pigs in lairage is not only a good indicator of welfare in terms of aggression and reaction to handling, but may also have direct consequences for their well-being. This might be influenced by how they are treated by stockpersons who have to drive them into the lairage pen and then to the slaughter area. A reduction in the ease of handling may result in more forceful and possibly aversive driving methods and therefore negatively affect their welfare. The models constructed from the results of this study only identify associations and not causal relationships between the measured environmental factors and the dependent indicators of welfare. However, this information is still useful in describing areas of the rearing environment that could be manipulated to improve the welfare of pigs in lairage as determined by behaviour at unloading, level of agonistic behaviour and skin lesions. These results suggest that grower and finisher pigs should be provided with straw bedding that may improve the ability of the pig to cope with the stressors associated with lairage conditions and adequate space allowance for the development of normal agonistic behaviour.



## **CHAPTER 5. INFLUENCE OF HUSBANDRY SYSTEM, TRANSPORT AND LAIRAGE ENVIRONMENT ON THE PREVALENCE OF ADVENTITIOUS BURSITIS**

### **5.1 Introduction**

Bursitis is a condition of the legs caused by traumatised capillaries and lymphatic vessels forming bursae - fluid-filled sacs - as a result of pressure on the skin over a bony prominence (Moultotou *et al.*, 1998a). Studies have shown that there is no pain due to this type of lesion (Backstrom and Henricson, 1966). However, its presence implies that the pig is being housed in an environment that is not sufficient as to avoid the discomfort, distress or injury outlined in UK welfare codes as being important in maintaining pig welfare (MAFF, 1991). Floor type has been demonstrated as being a major factor in determining the prevalence of bursitis in the pig, particularly the importance of providing soft bedding, such as straw or deep shavings (Moultotou *et al.*, 1998a, Moultotou *et al.*, 1999). However, floor type is not the only identified factor that can influence this disease. A survey of farms in the south-west of England also highlighted the importance of dunging area design and pen condition (Moultotou 1999). Other possible factors may include those affecting activity levels such as stocking density and group size (Ross and Curtis, 1976). Aspects of the transport process such as increased duration and distance may also exacerbate bursitis in the pig.

This survey was designed to identify factors within commercial rearing environments for pigs that were associated with increased prevalence of bursitis at the point of slaughter.

## 5.2 Materials and methods

This study took place in three abattoirs involving the same deliveries of pigs used in the transport and lairage study (see chapter four) and the gastric ulcer study (see chapter six).

### 5.2.1 Bursitis scoring

The hind legs of the carcasses of 50 pigs, which had previously been randomly selected for the collection of stomachs (see Chapter 4), were inspected for the presence of adventitious bursitis. Each of the hind legs was given a bursitis score from 0-3, according to the criteria presented in table 5.1 (based on the methods reported by Mouttotou *et al.*, 1998b):

**Table 5.1 Scoring method used in classifying the different levels of adventitious bursitis of the hind legs of pigs at slaughter.**

Bursitis score	Physical appearance
0	Indicates a normal limb (no lesions).
1	Indicates a small bursa (the size of a hazelnut).
2	Indicates a larger well-shaped bursa (the size of a walnut).
3	Indicates a bursa the size of a hen's egg.

### 5.3 Statistical analysis

The prevalence of adventitious bursitis was calculated by determining the percentage of pigs within a delivery that had a bursitis score greater than 0. Mean bursitis score was calculated from the 50 pigs from the delivery from each farm. This single farm score was used in the construction of a multiple regression model as in section 2.3. The correlation coefficient between ulcer score and bursitis score was calculated (see Chapter 4). All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

## 5.4 Results

The overall prevalence of bursitis was 42.3% with a mean bursitis score of  $0.8 \pm 0.12$  (see table 5.2).

**Table 5.2 Mean bursitis score and prevalence of adventitious bursitis on each farm in the study.**

Farm	Mean bursitis score	SEM	Percentage of pigs with bursitis score >0
a	0.1	0.04	12
b	0.9	0.16	46
c	0.5	0.14	26
d	1.8	0.14	86
e	0.0	0.00	0
f	1.3	0.25	65
g	0.0	0.03	3
h	0.5	0.14	30
i	-	-	-
j	0.9	0.20	50
k	1.1	0.14	68
l	1.4	0.18	62
m	0.7	0.13	44
n	0.2	0.08	16
o	2.6	0.11	96
p	0.5	0.11	30
Average	0.8	0.12	42.3

The first term in the predictive model for bursitis was the floor type for the finisher lying area. Pigs previously housed with straw bedding provided in the lying area had significantly reduced bursitis score compared to those kept on concrete, which in turn was significantly reduced relative to slatted flooring. The next term shows that increased transport distance resulted in higher bursitis scores. A straw bedded dunging area resulted in a further reduction in bursitis score relative to concrete and slatted floor types. The next terms in the model associated with an increase in bursitis score were the use of tail docking, lower numbers of grower pigs per room and managing grower pigs on an all-in all-out basis.

**Table 5.3 The multiple regression models for prevalence of adventitious bursitis on each farm in the study.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
√ Bursitis score	Constant <sup>1</sup>	0.751	0.317**	50.5
	+ Finisher slatted lying area	0.628		
	+ Finisher straw-bedded lying area	-0.271		
√ Bursitis score	Constant <sup>1</sup>	0.313	0.212***	77.8
	+ Finisher slatted lying area	0.649		
	+ Finisher straw-bedded lying area	-0.326		
	+ distance of transport	0.01009		
√ Bursitis score	Constant <sup>12</sup>	0.367	0.153***	88.5
	+ Finisher slatted lying area	0.576		
	+ Finisher straw-bedded lying area	-0.405		
	+ distance of transport	0.0106		
	+ Finisher slatted dunging area	-0.002		
	+ Finisher straw-bedded dunging area	-0.597		

<sup>1</sup> adjusted for Finisher concrete lying area<sup>2</sup> adjusted for Finisher concrete dunging area<sup>NS</sup> Non-significant i.e. T-probability p> 0.05

\*\*\* indicates an F-probability of p&lt;0.001

**Table 5.3 continued below**

Table 5.3 continued

√ Bursitis score	Constant <sup>12</sup>	0.183	0.123***	92.6
	+ Finisher slatted lying area	0.642		
	+ Finisher straw-bedded lying area	-0.253		
	+ distance of transport	0.00847		
	+ Finisher slatted dunging area	-0.001		
	+ Finisher straw-bedded dunging area	-0.580		
	+ Pigs tail-docked	0.274		
√ Bursitis score	Constant <sup>12</sup>	0.283	0.105***	94.6
	+ Finisher slatted lying area	0.581		
	+ Finisher straw-bedded lying area	-0.263		
	+ distance of transport	0.00788		
	+ Finisher slatted dunging area	0.036		
	+ Finisher straw-bedded dunging area	-0.533		
	+ Pigs tail-docked	0.267		
	+ No. growers per room	-0.000285		
√ Bursitis score	Constant <sup>1</sup>	0.338	0.0872***	96.3
	+ Finisher slatted lying area	0.461		
	+ Finisher straw-bedded lying area	-0.334		
	+ distance of transport	0.00834		
	+ Finisher slatted dunging area	-0.0041 <sup>NS</sup>		
	+ Finisher straw-bedded dunging area	-0.528		
	+ Pigs tail-docked	0.2060		
	+ No. growers per room	-0.000340		
	+ Growers managed all in all out	0.1410		

<sup>1</sup> adjusted for Finisher concrete lying area<sup>2</sup> adjusted for Finisher concrete dunging area<sup>NS</sup> Non-significant i.e. T-probability p> 0.05

\*\*\* indicates an F-probability of p&lt;0.001

## 5.5 Discussion

This study was designed to investigate the effects of the rearing environment on the prevalence and severity of adventitious bursitis in pigs at slaughter. The results have identified a number of significant management and environmental factors that mediate the variation of bursitis in pigs from a number of different commercial units.

The mean prevalence of adventitious bursitis in this study was 42.3 per cent, with a range of 0 per cent to 96 per cent in the 16 commercial units located in Cheshire, Staffordshire and Shropshire. This is similar to another recent study in the south-west of England reporting a mean prevalence of 51 per cent over 21 different units (Moultotou *et al.*, 1998a), but is less than an earlier study, again in the south-west of England, reporting a mean prevalence of 73.4 (Penny and Hill, 1974). The difference between these studies may be due to a greater proportion of straw based units investigated within the more recent study (Moultotou *et al.*, 1998a) and the current study in order to determine important risk factors from a range of commercial systems.

A study that investigated risk factors for bursitis using a random effects logistic regression model (Moultotou *et al.*, 1999) found that increasing age, increased time spent in the pen, a wet slurry film in the dunging area and a difference in height of greater than 3 cm between the lying and dunging areas were associated with increased bursitis prevalence. Bedding covering only the lying area or the whole pen were both found to be associated with significantly lower risk of bursitis. Moultotou *et al* (1999)

reported that bedding provided either in the lying area or over the whole pen was found to be associated with a reduced risk of bursitis, but floor type was found to be not significant in the final model. The current study had a number of results that supported these previous findings but found a number of other factors that could be considered of importance when assessing the risk of bursitis.

The lying area floor type in the finisher accommodation is the most important factor when predicting the prevalence of bursitis at slaughter according to the model generated in this study. A slatted lying floor is associated with a significantly higher bursitis score than a solid concrete floor, which in turn is associated with a significantly higher bursitis score than a straw bedded floor. Another study of finishing pigs on commercial units found very similar results in that pigs kept on solid floors with deep straw (>10 cm) had the lowest risk of having bursitis (Moultotou *et al.*, 1998a). The prevalence then increased successively when the floors were solid concrete with sparse straw (<10 cm), partially-slatted and fully slatted. As there was only one unit utilising deep straw bedding (>10 cm) for finishers in the current study no distinction was made between this and floors with lower amounts of straw. This reduced the chance of inappropriate emphasis being put on one factor that could be due to farm difference as demonstrated by Moultotou *et al.* (1998a). Straw bedding provides a more resilient substrate for the pigs to rest on and it is likely that the pressure on bony prominences is reduced further when pigs lie on straw than when they lie on hard surfaces such as bare concrete (Moultotou *et al.*, 1998a). The importance of straw bedding in the prevention of bursitis has also been demonstrated in other studies (Smith and Smith, 1980; Pearce, 1993) and



was found to reduce general skin lesions in a previous study including all of the farms in the current study (section 3.5.1).

The finding that increased transport distance between farm and abattoir was significantly associated with increased bursitis is a relationship not found in previous studies, although these investigations have been carried out mainly on the farm. It is likely that the increased bursitis was caused by extended standing times on a moving lorry exacerbated existing swellings. If this was the case this has important welfare considerations as the journey distances of this study were a maximum of 100 miles (maximum 210 minutes – table 4.2), while the national average is a journey of 2-3 hours but can be as high as 8 hours (Warriss and Bevis, 1986; Riches *et al.*, 1996).

It is unlikely that tail docking of pigs results in increased bursitis. The practice of tail docking is in order to reduce damage due to tail biting in pigs. It has been suggested that there are links between this procedure and poor environmental conditions due to associations with increased enteric disease (Pearce, 1999) which was also associated with slatted flooring. These diseases/factors are certainly interrelated which supports previous suggestions in this project that slatted flooring can compromise the welfare of the growing pig. It has been suggested that the increased risk of bursitis on a slatted floor is due to the pig supporting its weight on a smaller surface area (Moultotou *et al.*, 1998a). This would increase the pressure on the weight-bearing points and would therefore increase the risk of trauma to superficial lymphatic vessels, causing bursa development. This risk that could be increased by the use of rounded slats and reducing

the weight-bearing area of a slatted floor. Although the type of slat used on the farms in this study was not further categorised this may be an issue for further consideration.

The findings that increased grower numbers were associated with reduced bursitis is apparently in contrast with other studies that found an increased risk of bursitis at higher stocking densities (Smith, 1993; Mouttoutu *et al.*, 1998a). Mouttoutu *et al.* (1998a) suggested that, as pigs at a higher stocking density are less active than those at lower stocking densities (e.g. Ross and Curtis, 1976), the increased lying time may promote the formation of adventitious bursa or bursitis. However, a number of studies have reported a significant reduction in resting time with increasing group size (Ewbank and Bryant, 1969; Ross and Curtis, 1976; Randolph *et al.*, 1981). Therefore the current findings that increased group size during rearing reduced the risk of bursitis at slaughter suggest that the increased restlessness seen in larger groups and the presumable reduction in lying behaviour may inhibit the development of bursitis. This means that group size may be considered an important risk factor independent of stocking density, although stocking density was not included in the final model.

In this study all in/all out management of growers was associated with increased bursitis. This type of husbandry is associated with easy to clean/concrete environments and is carried out in order to reduce disease transfer between groups of pigs. There is no evidence of infection playing a part in the pathogenesis of adventitious bursitis (Marchant, 1980). Indeed if there were it could be expected that all in/ all out husbandry

would be associated with a reduction in bursitis so there must be some other aspect of this management procedure as yet uncovered.

## **5.6 Conclusions**

This study supports evidence of high prevalences of bursitis in finishing pigs, which is of welfare concern. The agreement between levels of prevalence between this and previous studies supports the validity of the regression model in predicting bursitis prevalence in finisher pigs at slaughter from commercial units. The current findings agree with previous studies that have reported the association of adventitious bursitis with floor type, particularly the increase observed on slatted floors and the beneficial effects of straw bedding. This study also identifies the association between adventitious bursitis and transport distance, which implies that increased distance from the abattoir can reduce the welfare of pigs. The importance of previous rearing environment is also demonstrated with the presence of independent variables from the grower stage in the model predicting bursitis score in finisher pigs at slaughter.

## CHAPTER 6. INFLUENCE OF HUSBANDRY SYSTEM ON THE PREVALENCE OF GASTRIC ULCERS OF PIGS AT SLAUGHTER.

### 6.1 Introduction

The incidence of ulceration of the pars oesophageal region of the stomach has increased with the intensification of pig production and the disease is reported in most countries of the world where pigs are kept intensively (Kowalczyk, 1969). The effects of diet, particularly feed processing methods, on the occurrence of gastric ulceration are well documented (reviewed by O'Brien, 1992; Kavanagh, 1994). O'Brien (1992) also suggested that "psychosomatic and other stress factors" might be important in the aetiology of this disease. However, there little information on how environmental stressors affect the prevalence of gastric ulcers in slaughter pigs.

Gastric ulceration in slaughter pigs has been reported to be associated with a number of signs indicative of poor welfare. Oral behaviour directed towards pen mates, suggested to be a behavioural indicator of stress (Dybkaer, 1994), was associated with increased stomach lesions (Dybkaer, 1994). Hessing *et al.* (1992) reported a tendency for an increase plasma cortisol, a commonly used physiological indicator of reduced welfare, with an increase in the severity of pars oesophageal lesions. Tuovinen and Schulman (1992) reported that 3.1% of growers died during transport from the farrowing unit or during the first week in finisher accommodation due to gastric ulcers. Potkins *et al.* (1989b) found indications of rearing system on prevalence of parakeratosis of the pars oesophageal region.

Therefore, there is strong evidence for prevalence of gastric ulcers being an important indicator of welfare.

This study was designed to investigate the prevalence of gastric ulceration in slaughter pigs and to ascertain whether there were any effects due to rearing environment and management factors on this measure of welfare. This work was part of a larger project investigating the welfare of pigs in lairage and at slaughter with respect to prior rearing conditions.

## **6.2 Materials and Methods**

This study took place in three abattoirs involving the same deliveries of pigs used in the transport and lairage study (see chapter four) and the bursitis study (see chapter five).

After the initial behavioural study in lairage (see Chapter 4) stomachs were collected in the abattoir from a random sample of 50 pigs of one delivery (or two deliveries if less than 50 per batch) from each farm. Sex and slaughter dead weight were taken from the abattoir database for each pig providing a stomach.

### 6.2.1 Gastric ulceration

The pars oesophageal region of each stomach was examined for the degree of gastric ulceration and given a score based on the protocol of Hessing *et al.*, (1992):

**Table 6.1 Scoring method used in classifying the different stages of ulceration of the pars oesophageal region of the pig's stomach.**

Score	Pathology
0	intact epithelium
1	small degree of hyperkeratosis (<50% of total surface)
2	Distinct hyperkeratosis stage 1 (>50% of total surface but <1mm thickness)
3	Distinct hyperkeratosis stage 2 (>50% of total surface but >1mm thickness)
4	Hyperkeratosis + less than five erosions smaller than 2.5 cm in diameter
5	Hyperkeratosis + more than five erosions and/or erosions larger than 2.5 cm in diameter
6	Hyperkeratosis + more than 10 erosions and/or erosions larger than 5 cm in diameter, and/or ulcers (with or without bleeding) or stenosis of the oesophagus towards the stomach

The presence of any bile staining was also noted and scored as 1 or 0 for each pig with a mean score then being calculated for each farm.

### 6.2.2 Particle size of finisher diet

A random sample of finisher ration from each farm was collected. The modulus of fineness of grinding (an indicator of particle size distribution) of the finisher diet was determined according to the method used by Hebblethwaite and Hempherd (1956). This measure of average particle size and is described as “the sum of the percentage of meal coarser than each of the screens, divided by 100” (Hebblethwaite and Hempherd, 1956). This gives a score of between 0 (finest grind) and 7 (coarsest grind) – the method of calculation is presented in figure 6.1.

Sieve size (inches)*	Weight on sieve (%)	Total percentage coarser than each sieve
3/8	$W_1$	$W_1$
3/16	$W_2$	$W_1 + W_2$
7 mesh	$W_3$	$W_1 + W_2 + W_3$
14 mesh	$W_4$	$W_1 + W_2 + W_3 + W_4$
25 mesh	$W_5$	$W_1 + W_2 + W_3 + W_4 + W_5$
52 mesh	$W_6$	$W_1 + W_2 + W_3 + W_4 + W_5 + W_6$
100 mesh	$W_7$	$W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7$
Less than 100	$W_8$	$W_1 + W_2 + W_3 + W_4 + W_5 + W_6 + W_7 + W_8$
Total	100	$7W_1 + 6W_2 + 5W_3 + 4W_4 + 3W_5 + 2W_6 + W_7$

\* each sieve has an aperture diameter equal to half that of the preceding sieve

$$\text{Modulus of Fineness of Grinding} = \frac{7W_1 + 6W_2 + 5W_3 + 4W_4 + 3W_5 + 2W_6 + W_7}{100}$$

**Figure 6.1 The method of calculating the modulus of fineness of grinding for a given meal sample (from Hebblethwaite and Hempherd (1956))**

In order to adapt this method for meal samples for use with pelleted diets the following method was suggested by Lawrence (1998, personal communication). 250g pellets were soaked in 1.5 litres of water so they easily disintegrated without much change to their physical characteristics. They were then sieved through muslin and dried out for approximately eight hours in a oven set at 65°C, (until they reached a moisture content of 16%). The samples were then subjected to a gentle shaking, before being sieved.

### **6.3 Statistical analysis**

The prevalence of gastric ulcers was calculated by determining the percentage of pigs within a delivery that had an ulcer score greater than 3. Mean ulcer score was calculated from the 50 pigs from the delivery from each farm. This single farm score was used in the construction of a multiple regression model as in section 2.3. Correlation coefficients were calculated between mean ulcer score, bursitis and P2 for each farm. The relationship between ulcer score and bile staining, also using farm means, was calculated by analysis of variance. The relationship between sex and ulcer score was calculated by analysis of variance using each animal as an individual unit. The relationship between provision of straw bedding for finishers and the occurrence of bile staining was calculated by analysis of variance using mean farm bile score. All analysis was carried out using Genstat for Windows statistics package (Genstat V, 1995).



## 6.4 Results

A summary of the descriptive statistics of all the farms involved in this study is presented in tables 4.2 and 4.3. The modulus of fineness of grinding had a median value of 3.10 with a range of 2.20 – 3.58.

### *6.4.1 Prevalence of gastric ulceration*

The overall prevalence of gastric ulcers (a gastric ulcer score >3) was 19.1% with a mean ulcer score of  $2.2 \pm 0.15$  (see table 6.4).

### *6.4.2 Relationships between ulcers, bile-staining, bursitis and sex*

There was a significant relationship between bile staining and gastric ulcer score (no bile staining vs. bile staining, 1.738 vs. 2.696 (sed = 0.0766),  $p < 0.001$ ). There was no significant effect of sex on gastric ulcer prevalence. Increased bursitis was significantly associated with increasing ulcer score (Ulcer score = 0.95 Bursitis score + 1.37,  $r^2 = 0.53$ ,  $p < 0.001$ ). There was a significant effect of provision of straw bedding for finishers and the mean occurrence of bile staining (bedding vs. no bedding, 0.246 vs. 0.640 (s.e.d. 0.1673),  $p < 0.05$ ).

### *6.4.3 Multivariate regression analysis results*

The results of the multivariate regression analysis are presented in table 6.5. The first term in the final model was finisher lying floor type. A slatted finisher lying floor was associated with a significantly higher mean ulcer score than a solid concrete floor, which was in turn significantly higher than a straw-bedded floor. The next term was the significant effect of a pelleted finisher ration on increasing mean ulcer score.

**Table 6.2. Mean ulcer score and prevalence of gastric ulcers on each farm in the study.**

Farm	mean ulcer score	SEM	Percentage of pigs with ulcer score >3
a	1.5	0.11	0
b	1.3	0.11	0
c	2.5	0.19	22
d	3.7	0.14	60
e	0.5	0.13	0
f	2.9	0.29	35
g	0.9	0.15	0
h	1.3	0.11	0
I	3.1	0.16	36
j	2.8	0.21	34
k	1.9	0.11	4
l	2.4	0.10	6
m	1.8	0.07	2
n	2.5	0.15	16
o	3.5	0.19	58
p	2.8	0.17	32
Average	2.2	0.15	19.1

**Table 6.3 The multiple regression models for prevalence of gastric ulcers on each farm in the study.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Ulcers	Constant <sup>1</sup>	2.271	0.624***	62.1
	+ Finisher slatted lying area	0.904		
	+ Finisher straw-bedded lying area	-1.129		
Ulcers	Constant <sup>1</sup>	1.796	0.374***	87.5
	+ Finisher slatted lying area	0.904		
	+ Finisher straw-bedded lying area	-0.891		
	+ Finisher pelleted diet	0.951		

<sup>1</sup> adjusted for Finisher concrete lying area

\*\*\* indicate an F-probability of &lt;0.001

## 6.5 Discussion

There is little information currently available on the effects of rearing environment on the prevalence of gastric ulcers in pigs at slaughter. The results of the current study have identified a number of significant management and environmental factors that mediate the variation in the prevalence of ulceration of the pars oesophageal region of the stomach of pigs from a number of different commercial units.

The prevalence of gastric ulcers in this study was 19.1% of pigs with an ulcer score greater than 3 according to the criteria stated in section 6.2.1. O'Brien (1992) reported that prevalences for pars oesophageal ulceration ranged from 5-100% world-wide (England = 29 per cent prevalence).

The significant association between gastric ulceration and bursitis is not one previously reported. As there appears to be no actual pain due to this type of lesion (Backstrom and Henricson, 1966) the bursitis would not be considered to be a stressor in itself, so this is unlikely to be a direct causal relationship. The association is more likely to be due to a common causality of these two conditions related to confinement housing, which is possibly slatted flooring (see chapter 5).

### 6.5.1 Bile score

The results of the current staining showing an increase in mean ulcer score in those stomachs with bile staining supports suggestions of such a relationship (Reed and Kidder, 1970). Rayner and Wenham (1986) state the most likely reason for bile staining is the close proximity of the bile duct orifice to the pyloric sphincter. This reflux of bile into the stomach may have some importance in the erosion of epithelial tissue that occurs in the formation of gastric ulcers (Lawrence *et al.*, 1980).

### 6.5.2 Stomach ulcer (*pars oesophageal region*) score

In a survey of US slaughter pigs Backstrom *et al.*, (1988) reported prevalences of 'esophagogastric erosions/ulcers' (approximately an ulcer score of 3 or more by the criteria used in the current study) of 21.2% and 15.3% for males and females, respectively. However, no sex difference was found during this study, although ulcer prevalences were similar to those reported by Backstrom *et al.*, (1988).

Lying floor-type of the finisher pigs was the most important factor in determining mean ulcer score. The association between slatted floors and an increase in gastric ulceration is not one previously recognised. It has been demonstrated that ulceration of the *pars oesophageal* region can be caused by the fasting of pigs (Chamberlain *et al.*, 1967; Pocock *et al.*, 1968; Davies *et al.*, 1994; Straw *et al.*, 1994; Lawrence *et al.*, 1998). Therefore it is

probable that environmental stressors could contribute to gastric ulceration by causing dietary interruption. Environmental stressors that have already been identified as being associated with gastric ulceration include large group size (Backstrom *et al.*, 1988), transport (Lawrence *et al.*, 1998) and social ranking (Hessing *et al.*, 1992). A tentative link between pathogenic infection and gastric ulcers has been suggested (Smith, 1980) and it is well known that illness can reduce food intake and therefore cause dietary interruption (Kelley *et al.*, 1993). Partially-slatted floors have been identified as a risk factor for enteric disease (Pearce, 1999). Slatted flooring has also been associated with increased skin lesions, respiratory disease, tail-biting (see chapter 3) and bursitis (see chapter 5), which may all lead to fasting in pigs, reported to induce gastric ulcers (Lawrence *et al.*, 1998). The current findings suggest that stressors associated with housing pigs on a fully slatted floor may be sufficient to cause a significant increase in gastric ulceration, which is probably due to an interruption in food intake. According to Jensen *et al.* (1996) there is no effect of chronic intermittent stress (inescapable electric shocks in this study) on gastric ulceration in pigs although environmental stressors in other species are commonly associated with gastric lesions (Moody *et al.*, 1976). However, Dybkjaer (1994) found that in pigs certain behavioural signs (exploratory behaviours directed at pen mates) purported to represent “mental stress” were associated with increased keratinisation of the pars oesophageal region, the preliminary stage of gastric ulceration. These behavioural signs have also been observed in pigs kept in barren environments (McKinnon *et al.*, 1989; Wood-Gush and Vestergaard, 1991). It is therefore likely that the lack of environmental stimulation in the barren environment of a fully slatted finisher pen is a sufficient stressor to cause increased gastric ulceration, at least in part, in the pigs involved in this study.

In addition to the association of slatted floors and increased ulceration, straw is associated with a significant reduction in the average severity of gastric ulcers. This supports the findings of previous studies that providing straw bedding as a substrate can ameliorate the damaging effects of feeding a finely ground diet (Nielsen and Ingvarsten, 2000). It is also possible that on the farms in this study straw is providing a source of environmental enrichment (see section 2.5.2), improving the ability of pigs to cope with environmental stressors. However, the dietary effects of straw are likely to be of more importance in mediating stomach ulceration (Nielsen and Ingvarsten, 2000). Crude fibre has been reported to have ameliorating effects on the development of gastric lesions (Potkins *et al.*, 1989a). It has been suggested that the additional dietary fibre may break up the more fluid digesta from fine diets, preventing the erosion of the pars oesophageal region (Potkins *et al.*, 1989a). Therefore, the presence of straw bedding allows an additional dietary fibre source that prevents damage caused by modern finishing diets, which are more finely ground for increased digestibility.

Besides floor type, the other significant factor found in this study to be associated with a significant increase in the presence of gastric ulcers, is the feeding of pelleted feed. This supports the suggestions of a growing number of authors that feeding pelleted diets can cause a significant increase in the incidence and severity of ulcers (e.g., Wondra *et al.*, 1995b; Potkins *et al.*, 1989a). The high temperatures used during the pelleting process can cause gelatinisation of the cereal starches during the processing of pellets that has been suggested to promote the development of gastric ulcers (Wondra *et al.*, 1995b). Potkins *et*

*al.* (1989a) also found that feeding a pelleted diet based on coarsely ground barley had similar effects to feeding a finely ground barley diet fed as meal in that lesion development was increased.

## 6.6 Conclusions

This study supports evidence of high prevalences of gastric ulcers in slaughter pigs. The current findings agree with previous studies that have reported the association of ulceration of the pars oesophageal region of the stomach and the feeding of pelleted diets. This study also identifies the association between slatted floors and increased ulceration and the results suggest that the provision of straw bedding is beneficial in terms of this measure of pig welfare.



## **CHAPTER 7. INFLUENCE OF REARING CONDITIONS AND RESPIRATORY DISEASE ON ACUTE PHASE PROTEIN LEVELS IN THE PIG AT SLAUGHTER**

### **7.1 Introduction**

It has been suggested that almost a third of the genetic potential of modern pigs is not being realised (Robertson, 1998) indicating a significant capacity for improving pig production. A reduced growth rate is a possible indicator that a pig is unable to cope with its present environment and is therefore suffering from a reduction in welfare (Broom, 1986). Recent work has demonstrated that rearing pigs in a commercial environment can reduce live weight, lean and fat tissue growth to 70 per cent of that achieved in an unrestricted research environment (Holck *et al.*, 1998). The variability between the growth rates of the pigs in these two environments was mainly attributed to subclinical respiratory disease. Straw (1991) found that pigs from a herd with a high prevalence and severity of pneumonia reared in a commercial environment during the grower/finisher stage also had a significant reduction in daily live weight gain compared with those reared in an improved environment. However, in this study pneumonia lesions evaluated at slaughter did not differ between treatment groups.

Holck *et al* (1998) have suggested that the response of a pig to its environment may be monitored by using physiological markers, or “biomarkers”. Acute phase proteins are produced by the liver in response to cytokines associated with inflammation, infection or tissue injury and function to restore homeostasis in the body following injury or

infection (Holck *et al.*, 1998). Haptoglobin, C-reactive protein, Major Acute Phase protein and Serum Amyloid A have all been identified as sensitive indicators of infection (with *Actinobacillus pleuropneumoniae*) and have been suggested as possibilities for non-specific surveillance of pig health status (Heergaard *et al.*, 1998).

Although there is an increasing number of scientific publications describing the acute phase response of the pig and the effects of infection (Heergaard *et al.*, 1998), inflammatory response to an injection of turpentine (Eckersall *et al.*, 1996) and specific husbandry practices (Francisco *et al.*, 1996a; Francisco *et al.*, 1996b), there is little information describing the effects of the rearing environment on mediating the variability of acute phase proteins in the slaughter pig. Knowledge of such variation may be important in identifying factors within husbandry systems associated with increased acute phase response and also in ante- and post-mortem inspection in order to reduce the number of condemned carcasses (Saini and Webert, 1991).

This study was designed to investigate further the relationship between pathological signs of respiratory disease and serum acute phase protein concentrations. In order to continue to assess the effects of rearing environment on the health and welfare of commercial finishing pigs this study also will identify which husbandry and management procedures were important in influencing signs of respiratory disease and the acute phase response, as determined by levels of serum acute phase proteins, in slaughtered pigs reared under commercial conditions.

## 7.2 Materials and Methods

Seventeen farms were involved in the study that delivered pigs to one of three participating abattoirs. Each farmer was given a questionnaire detailing various aspects of the farm environment, husbandry system and pig health based on a previous study investigating risk factors for respiratory diseases in New Zealand (Stark *et al.*, 1998). Blood samples and lungs were collected from 30 randomly selected pigs from a single delivery.

### 7.2.1 Blood Analysis

Following stunning, blood samples were collected in 30 ml universal tubes from the throat as they were exsanguinated. The collected blood was left to clot overnight and serum was obtained after clotting by centrifugation for 15 minutes at 3000 rpm and stored at -20°C until use. The blood samples were subsequently analysed for the following acute phase proteins.

#### 7.2.1.1 Haptoglobin

The serum haptoglobin concentration was determined by using an assay established to measure haptoglobin by haemoglobin binding activity in bovine serum (Conner *et al.*, 1988) that has been quantified by comparison to purified porcine haptoglobin (P.D. Eckersall, personal communication).

#### 7.2.1.2 C-reactive Protein (CRP)

The serum C-reactive protein was measured by a modification of an enzyme linked immunosorbent assay originally developed for canine C-reactive protein (Eckersall *et al.*, 1989a; Eckersall *et al.*, 1989b) using rabbit antiserum to porcine C-reactive protein (Department of Clinical Biochemistry, University of Glasgow).

#### 7.2.1.3 Major Acute Phase Protein (MAP)

Pig-MAP was isolated from the serum samples according to the method of Gonzalez-Ramon *et al.* (1995). Analysis of the individual Pig-MAP protein was performed by radial immunodiffusion in 1% agarose gel containing a specific rabbit antiserum against the protein, using the purified protein as a reference standard.

#### 7.2.1.4 Serum Amyloid A (SAA)

Levels of Serum Amyloid A were determined according the method of Boosman *et al.* (1989) adapted for use with pigs utilising an indirect ELISA-method.

#### 7.2.1.5 Albumin and Total Protein

Analysis for albumin and total protein was carried out using a Bayer RA-1000 autoanalyser (Bayer plc, Strawberry Hill, Newbury Berkshire, GR14 1LA) and the kits of Bayer (Product numbers T01-1377-02 and T01-1301-02, respectively).

### 7.2.2 Respiratory lesions

Each farm was assessed for their pneumonia status by calculating the prevalence of affected lungs at slaughter and their degree of consolidation. In order to determine tissue damage due to enzootic pneumonia (EP score) the degree of consolidation was assessed by estimating the percentage of the surface of each lobe of the lung showing signs of consolidation. This percentage was multiplied by a weighting factor for each lobe (0.25 for the caudal lobes, 0.1 for the cranial and accessory lobes - based on their relative volumes) and totalled to give a score out of 100 for each pig. In order to determine tissue damage due to pleuropneumonia (PL score) the percentage of each lobe estimated to be missing due to adhesion of pleural membranes was scored as for enzootic pneumonia. Although pleuritis can be attributed to a number of causal organisms, infection with *Actinobacillus pleuropneumoniae* is by far the most common (Done, 1999).

### 7.3 Statistical Analysis

Descriptive statistics were calculated for the continuous variates (i.e. median, minimum and maximum). Differences in acute phase protein and total protein concentration between pigs identified as having or not having clinical signs of enzootic pneumonia were calculated using the Kruskal-Wallis statistical technique. This was repeated for those identified as having or not having clinical signs of pleuropneumonia. In addition, both types of pneumonia were considered together by creating four groups, one negative for both types, one positive for EP only, one positive for PL only and one positive for both types. Box plots were drawn to show the four groups in order to visualise the data for further discussion. Regression equations were calculated to determine whether either pneumonia score could be predicted by the actual serum acute phase protein concentration. The continuous and discontinuous data concerning the farm factors were used to create multiple regression models according to the method described in section 2.3. All calculations were carried out using Genstat for Windows statistical software (Genstat V, 1995).

## 7.4 Results

### 7.4.1 *Descriptive statistics*

Of the 17 farms that took part in this study eight were breeder-finisher units and 9 were finishing-only units, all slaughtering between 90-100 kg live weight. Nine farms provided bedding for their grower pigs, while eight provided bedding for the finishers. Nine farms used a slatted method of slurry disposal for their growers, while 10 used slatted floors for their finishers. Five farms vaccinated against enzootic pneumonia, one farm vaccinated for pleuropneumonia, four farms injected individual grower pigs for treatment of respiratory disease and one farm injected finisher pigs for treatment of respiratory disease. Ten farms gave in-feed/water medication to their growers and five farms gave in-feed/water medication to their finishers. Descriptive results for the continuous variables are shown in table 7.1.

### 7.4.2 *Prevalences of signs of enzootic and pleuro-pneumonia*

Clinical signs of enzootic pneumonia was the most prevalent lesion type in this study with 147 pigs out of the 510 examined showing pathological lesions (varying from 0-26 % of total lung volume affected). Only one of the 17 farms did not show signs of enzootic pneumonia. Pathological damage attributed to pleuropneumonia was found in 34 of the 510 pigs examined (signs of pleurisy varying from 0-48 % of total lung volume affected in all pigs). Four out of the 17 farms did not show the lung tissue damage attributed to pleuropneumonia in this study. Distributions of lesion scores are presented in table 7.2. Eleven out of the 510 pigs showed signs of both diseases.

**Table 7.1 Descriptive statistics of continuous management variables from the respiratory disease and acute phase protein study.**

	Median	Minimum	Maximum
No. sows	78	0 (finishers only)	491
Distance to nearest pig farm (miles)	2	0.25	5
Distance to nearest pig farm upwind (miles)	3	0.25	7
Weaning age	24	21	28
No. stages after weaning	2	1	4
Grower pen size (m <sup>2</sup> )	12.5	5	100
No. grower pigs per pen	25	14	200
Grower space allowance(m <sup>2</sup> /pig)	0.5	0.36	1.25
No. grower pigs per room	140	20	290
Finisher pen size (m <sup>2</sup> )	13.3	6.75	100
No. finisher pigs per pen	20	10	200
Finisher space allowance(m <sup>2</sup> /pig)	0.68	0.47	0.93
No. finisher pigs per room	149	100	220

**Table 7.2 Distribution of the severity of lesion scores for enzootic pneumonia and pleuropneumonia.**

Pneumonia score (%)	Enzootic pneumonia (%, n=510)	Pleuropneumonia (%, n=510)
0	71.2	93.3
>0-1	5.9	0.0
>1-2	7.1	0.8
>2-5	9.0	1.6
>5-10	3.3	1.8
>10-20	2.9	1.8
>20-30	0.6	0.2
>30-40	0	0.4
>40-50	0	0.2
>50	0	0



**Table 7.3 Median, minimum and maximum values for each acute phase protein and total protein from the respiratory disease and acute phase protein study.**

	Median	Minimum	Maximum
Haptoglobin (mg.ml <sup>-1</sup> )	0.3	0.0	8.6
MAP (mg.ml <sup>-1</sup> )	0.8	0.2	6.5
SAA (µg.ml <sup>-1</sup> )	8.0	2.2	834.6
CRP (µg.ml <sup>-1</sup> )	19.7	0.0	437.0
Albumin (mg.ml <sup>-1</sup> )	36.6	23.9	46.0
Total Protein (mg.ml <sup>-1</sup> )	75.3	60.7	96.4

**Table 7.4 Results of the Kruskal-Wallis statistical analysis of negative and positive Enzootic Pneumonia and the acute phase proteins and total protein**

	EP negative	EP positive
Haptoglobin (mg.ml <sup>-1</sup> )	0.3	0.4**
MAP (mg.ml <sup>-1</sup> )	0.8	0.8
SAA (µg.ml <sup>-1</sup> )	8.0	8.0
CRP (µg.ml <sup>-1</sup> )	19.6	20.0
Albumin (mg.ml <sup>-1</sup> )	36.7	36.4
Total Protein (mg.ml <sup>-1</sup> )	75.4	74.7

\*\* indicates significance  $p < 0.01$

**Table 7.5 Results of the Kruskal-Wallis statistical analysis of negative and positive Pleuropneumonia and the acute phase proteins and total protein**

	PL negative	PL positive
Haptoglobin (mg.ml <sup>-1</sup> )	0.3	0.3
MAP (mg.ml <sup>-1</sup> )	0.8	0.8
SAA (µg.ml <sup>-1</sup> )	8.0	8.0
CRP (µg.ml <sup>-1</sup> )	20.0	15.6
Albumin (mg.ml <sup>-1</sup> )	36.8	35.7
Total Protein (mg.ml <sup>-1</sup> )	75.4	73.6

**Table 7.6 Results of the Kruskal-Wallis statistical analysis of the 510 pigs grouped for no signs of respiratory disease, enzootic pneumonia only, pleuropneumonia only and both diseases and the acute phase proteins and total protein (results shown are median values)**

	Negative	EP positive only	PL positive only	EP & PL positive	Significance
Haptoglobin (mg.ml <sup>-1</sup> )	0.2	0.5	0.4	0.3	*
MAP (mg.ml <sup>-1</sup> )	0.8	0.8	0.8	0.7	*
SAA (µg.ml <sup>-1</sup> )	8.0	8.0	8.5	7.0	*
CRP (µg.ml <sup>-1</sup> )	20.0	20.1	15.6	19.5	NS
Albumin (mg.ml <sup>-1</sup> )	36.8	36.7	36.1	35.4	NS
Total Protein (mg.ml <sup>-1</sup> )	75.5	74.7	73.3	73.6	NS

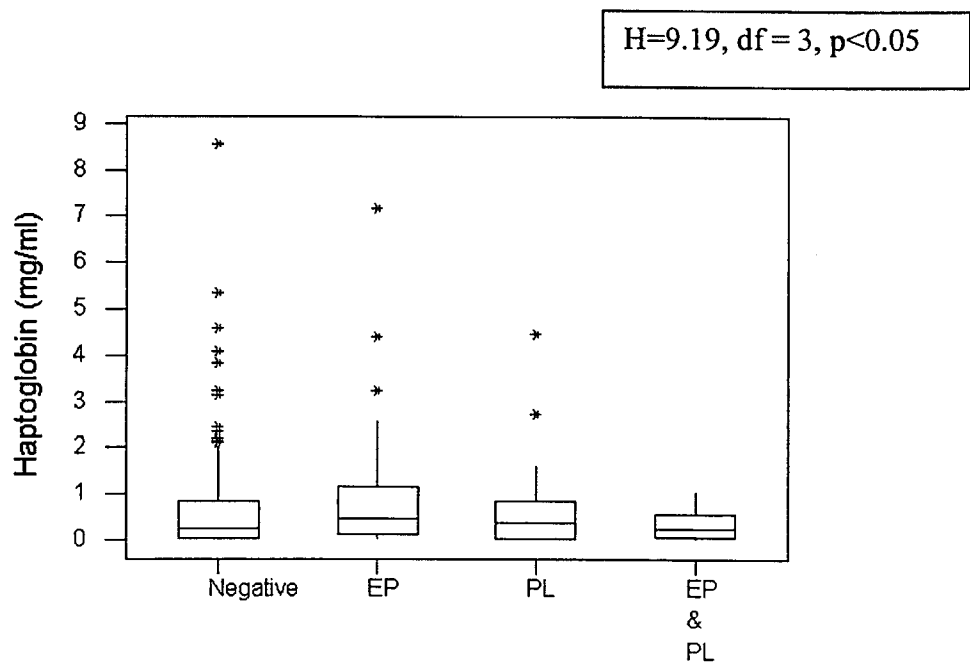
\* indicates significance  $p < 0.05$ , NS indicates not significant ( $p > 0.05$ )

#### 7.4.3 Acute phase proteins

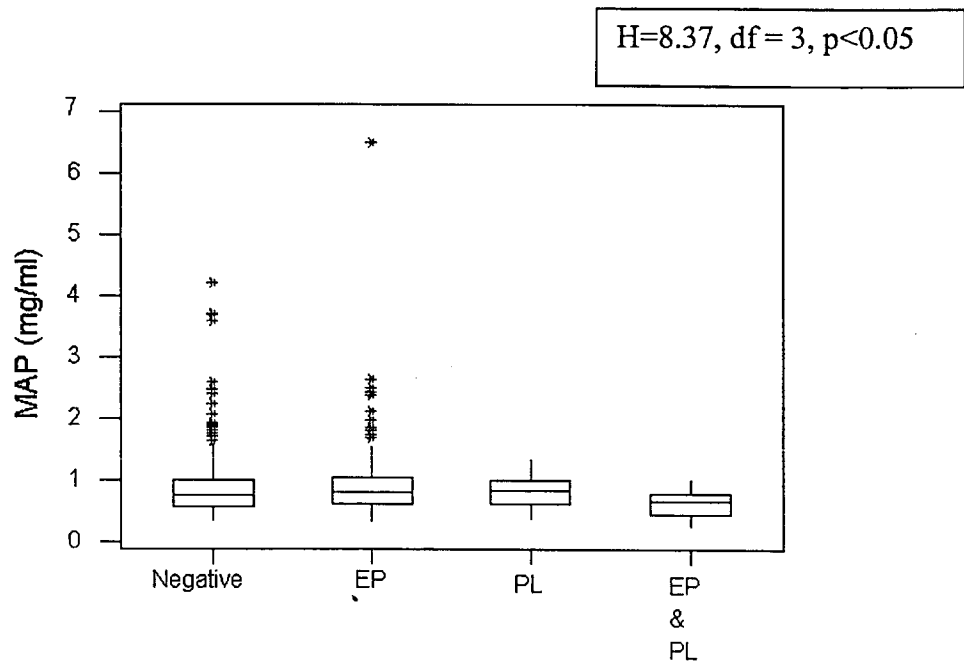
The medians and range of the acute phase data are presented in table 7.3. There was a significant increase in haptoglobin concentration in those pigs identified as being previously EP positive compared to those without clinical signs of this disease ( $p < 0.01$  – table 7.4). There were no other significant differences between pigs that were negative or positive for EP in their acute phase protein or total protein concentrations. There were no significant differences in any of the measured proteins between pigs negative or positive for clinical signs of pleuropneumonia (table 7.5).

When considering both types of pneumonia together, analysis showed significant differences for haptoglobin, MAP and SAA (all  $p < 0.05$ ), but not CRP, albumin or total protein (see table 7.6 and figures 7.1, 7.2 & 7.3).

There was no significant relationship, linear or otherwise, between EP lesion score or PL lesion score and any of the measured acute phase proteins or total protein.



**Figure 7.1 Serum Haptoglobin concentrations of pigs identified as negative for EP and PL, having either or both conditions.**



**Figure 7.2 Serum Major Acute Phase protein concentrations of pigs identified as negative for EP and PL, having either or both conditions.**

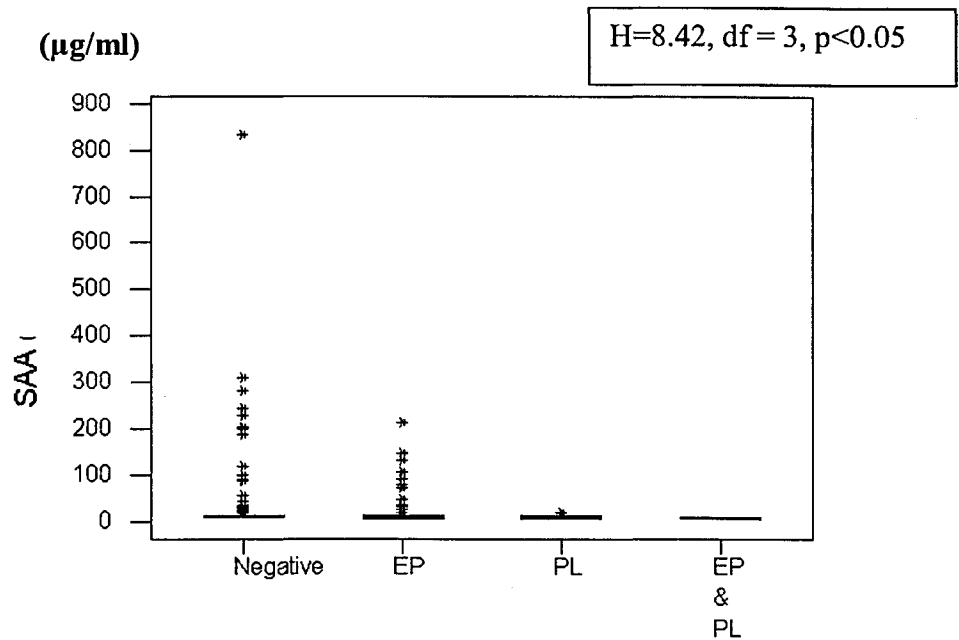


Figure 7.3 Serum Amyloid A concentrations of pigs identified as negative for EP and PL, having either or both conditions.

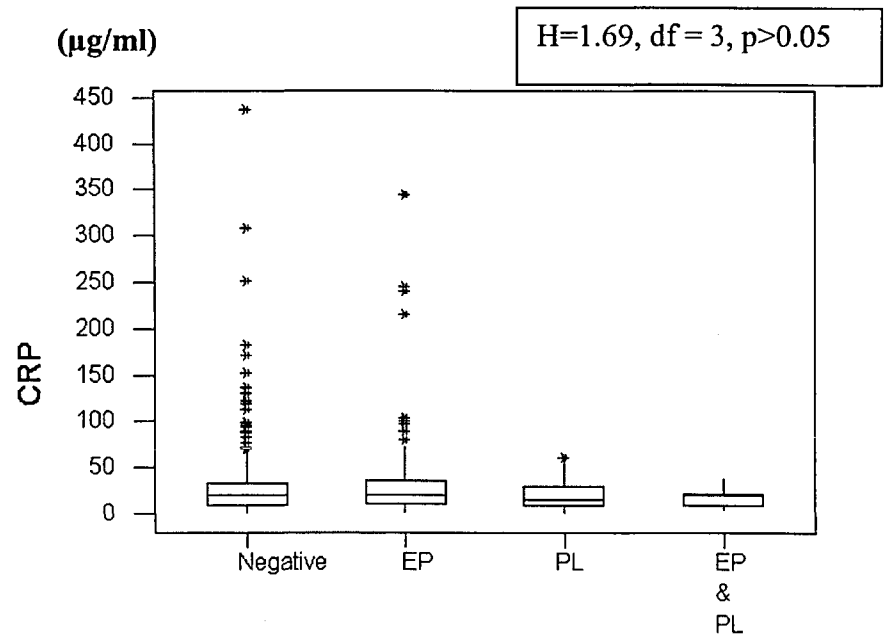
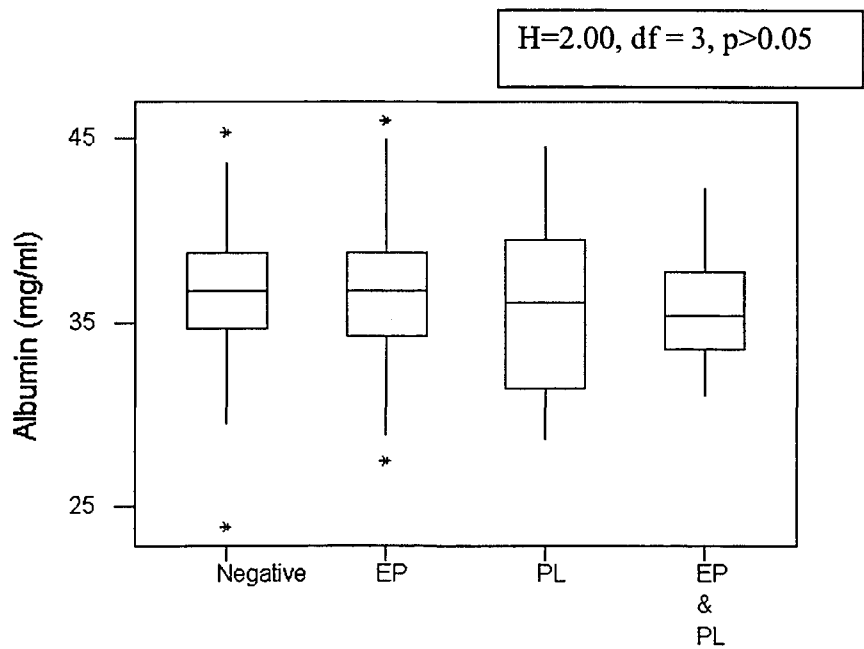
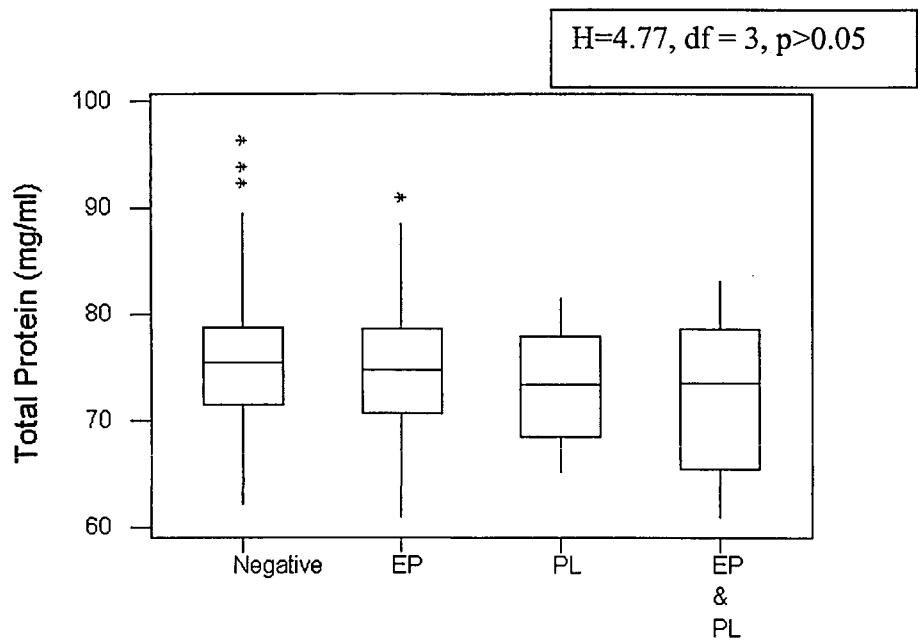


Figure 7.4 Serum C-reactive protein concentrations of pigs identified as negative for EP and PL, having either or both conditions.



**Figure 7.5 Serum Albumin protein concentrations of pigs identified as negative for EP and PL, having either or both conditions.**



**Figure 7.6 Serum Total Protein concentrations of pigs identified as negative for EP and PL, having either or both conditions.**

**Table 7.7 The multiple regression models for the Enzootic and Pleuropneumonia measurements for pigs at slaughter.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	$r^2$
Enzootic pneumonia score	Constant + Grower ventilation fan assisted	0.882 1.357	1.14*	22.4
Pleuropneumonia score	Constant + Breeder/finisher unit	1.194 -0.960	0.930*	23.1
% positive enzootic pneumonia	Constant + Finishers individually injected for treatment	0.2583 0.508	0.239*	22.1
% positive pleuropneumonia	Constant + Finisher slatted dunging area	0.0190 <sup>NS</sup> 0.0810	0.0619*	32.0
% positive pleuropneumonia	Constant + Finisher slatted dunging area + Finisher ventilation fan assisted	0.0310 <sup>NS</sup> 0.1009 -0.0775	0.0520**	55.1
% positive pleuropneumonia	Constant + Finisher slatted dunging area + Finisher ventilation fan assisted + Finishers wet fed	0.0208 <sup>NS</sup> 0.0922 -0.0940 0.0821	0.0381***	77.7

**Table 7.8 The multiple regression models for the acute phase measurements for pigs at slaughter.**

Dependent variable	Fitted terms in regression model	Regression coefficient	Standard error of observations	r <sup>2</sup>
Haptoglobin (mg.ml <sup>-1</sup> )	Constant + Finisher pens separated by solid partitions	0.8485 -0.394	0.238**	44.0
Haptoglobin (mg.ml <sup>-1</sup> )	Constant + Finisher pens separated by solid partitions + Finisher pen size (m <sup>2</sup> )	0.9938 -0.446 -0.00585	0.205**	61.5
MAP (mg.ml <sup>-1</sup> )	Constant + Growers provided with bedding	0.8378 0.1240	0.126*	21.4
MAP (mg.ml <sup>-1</sup> )	Constant + Growers provided with bedding + Finisher ventilation fan assisted	0.7327 0.2057 0.2101	0.0894***	63.3
MAP (mg.ml <sup>-1</sup> )	Constant + Growers provided with bedding + Finisher ventilation fan assisted + Finishers individually injected for treatment	0.7242 0.2185 0.1716 0.2222	0.0749***	76.1
lnSAA (µg.ml <sup>-1</sup> )	Constant + Growers individually injected for treatment	2.801 -0.561	0.348*	38.9
CRP (µg.ml <sup>-1</sup> )	Constant + Pigs over 12 weeks share room with pigs that are 5 weeks younger	25.37 20.32	11.7*	33.2
CRP (µg.ml <sup>-1</sup> )	Constant + Pigs over 12 weeks share room with pigs that are 5 weeks younger + Finisher pigs have ad lib access to drinking water	46.8 21.96 -23.0	10.6**	49.2
CRP (µg.ml <sup>-1</sup> )	Constant + Pigs over 12 weeks share room with pigs that are 5 weeks younger + Finisher pigs have ad lib access to drinking water + Vaccinated against enzootic pneumonia	58.7 18.29 -31.3 -11.94	9.47**	62.1
Albumin (mg.ml <sup>-1</sup> )	Constant + Growers effluent removed daily	34.626 -3.182	1.61**	49.0
Albumin (mg.ml <sup>-1</sup> )	Constant + Growers effluent removed daily + Vaccinated against enzootic pneumonia	34.249 -3.045 1.888	1.40**	63.9
Total protein (mg.ml <sup>-1</sup> )	Not significant			



#### *7.4.4 Multiple regression models for pneumonia scores and acute phase proteins*

From a relatively large number of input variables very few remained in the final multiple regression models for each type of pneumonia, the farm mean acute phase protein and total protein concentrations. Breeder-finisher units were associated with a lower level of pleuropneumonia than units that produced finishers only. The use of fan assisted ventilation was associated with an increase in enzootic pneumonia and MAP and a decrease in the number of pleuropneumonia cases per farm within their individual models. The provision of bedding was also associated with an increase in MAP. The use of slatted flooring for slurry disposal was associated with an increase in the number of pleuropneumonia cases per farm. Vaccination for enzootic pneumonia was associated with a decrease in CRP. The individual treatment of pigs for respiratory disease by injection was associated with an increase in the number of enzootic pneumonia cases per farm and MAP concentration, but a reduction in SAA concentration (although this was in growers as opposed to the finishers in the other two cases). Solid pen divisions in the finisher accommodation were associated with a reduction in haptoglobin concentration. Rooms containing pigs of more than five weeks difference in age were associated with an increase in CRP. Other predictors of lesser importance in terms of percent variance accounted for included pen size (associated with a reduction in haptoglobin), ad libitum access to drinking water for finishers (associated with a reduction in CRP) and daily removal of effluent (associated with a reduction in albumin). Table 7.7 shows the final multiple regression models for the level of each of the types of pneumonia studied and the number of cases of each type per farm, while table 7.8 shows the predictive models of the acute phase proteins and total protein.

## 7.5 Discussion

### 7.5.1 *Enzootic and Pleuro-pneumonia prevalence*

Respiratory lesions in pigs at slaughter are common in the UK. Done (1999) reports that the prevalence of enzootic pneumonia in the UK can be as high as 90 per cent, although the average remains about 50 per cent (Done, 1999). This average figure is higher than the 29 per cent prevalence of enzootic pneumonia found in the current study, although prevalence of pneumonia is known to be reduced during the summer months (Stark *et al.*, 1998). Figures are similar for other pig producing countries of similar climates (52 percent in New Zealand (Stark *et al.*, 1998); 84 per cent in Sweden (Wallgren *et al.*, 1994a); 70 per cent in Norway (Lium and Falk, 1991); 75 per cent in Ontario, Canada (Wilson *et al.*, 1986)).

In terms of the severity of the enzootic pneumonia lesions, the majority (76 per cent) of the lesions seen in pigs showing signs of disease affected under five per cent of the total lung volume (shown in table 7.2). Twenty-two percent of the lesions affected between 5 and 20 percent with the remaining two percent affecting more than 20 per cent of the lung tissue (by volume). The distribution of the severity of the pleuropneumonia score lesions is slightly different being 35 per cent, 53 per cent and 12 per cent for scores of 0-5, 5-20 and more than 20 per cent, respectively. This may reflect that the scoring system employed, i.e. the estimation of tissue missing rather than actual infection, is likely to over estimate the proportion of lung tissue affected.

There is little information as to actual prevalence of *Actinobacillus pleuropneumoniae* infection in the UK, more often the presence of pleuritis (the formation of pleural

membranes) is recorded and has been reported as being less than 20 per cent in the UK (Done, 1999). However, Done (1999) states that *Actinobacillus pleuropneumoniae* is the most likely candidate to be the cause of this condition. This is similar to the seven per cent prevalence for pigs showing pleuritis in the current study, as is the case for enzootic pneumonia this disease is also expected to be reduced in the summer months (Stark *et al.*, 1998). Figures are rare for other countries for actual pleuropneumonia (2.7 per cent in New Zealand (Stark *et al.*, 1998) but are more common for pleuritis, which was measured in this study (19.1 percent in New Zealand (Stark *et al.*, 1998); 6 per cent in Sweden (Wallgren *et al.*, 1994a); 29 per cent in Norway (Lium and Falk, 1991); 11 per cent in Ontario, Canada (Wilson *et al.*, 1986)).

### 7.5.2 Acute Phase Protein distributions

#### 7.5.2.1 Haptoglobin

In addition to being used for monitoring infectious disease progression it has been suggested that acute phase protein measurements can be used for the prognosis and diagnosis of disease and for the evaluation of general health status (Heergaard *et al.*, 1998). One of the aims of this study was to evaluate the relationship between pathological signs of respiratory disease and serum concentration of acute phase proteins in pigs at slaughter weight (90-110 kg). Of the six proteins measured in this study only haptoglobin showed a significant increase (0.26 to 0.43 mg.ml<sup>-1</sup>,  $p < 0.01$ ) in pigs that showed pathological signs of enzootic pneumonia compared to those that did not. The magnitude of this increase was less than two times. Normal levels of serum haptoglobin concentrations vary, but are generally quoted as being less than 0.5 mg.ml<sup>-1</sup> (Heergaard *et al.*, 1998). In a study of a conventional herd, Eurell *et al.*, (1992) found

levels varying between 0.1 and 0.6 mg.ml<sup>-1</sup> compared to the range of 0 – 8.55 mg.ml<sup>-1</sup> found in the current study. Others have reported normal levels as low as 0.06 mg.ml<sup>-1</sup>, a mean of 0.19 mg.ml<sup>-1</sup> in a herd chronically infected with pleuropneumonia and a mean of 0.24 mg.ml<sup>-1</sup> in a herd undergoing acute *Actinobacillus* infection (Hall *et al.*, 1992). The higher levels found in the current study are probably due to the use of porcine haptoglobin as a standard in the current study instead of the human haptoglobin used by Hall *et al.* (1992), this having also previously suggested by Heergaard *et al.* (1998).

Although infection with *Mycoplasma hyorhinis* has been shown to be associated with an increase in serum haptoglobin concentration (Magnusson *et al.*, 1999), this is the first report finding a relationship between pathological signs of enzootic pneumonia (caused by infection with *Mycoplasma hyopneumonia*) and haptoglobin. However, no relationship was found with any of the other measured proteins. The degree of pathological lesions was not significantly associated with differences in serum haptoglobin. This may be due to the fact that these lesions are likely to be residual from a previous infection rather than reflecting a current acute condition. Other work in cattle (Horadagoda *et al.*, 1999) has shown that in cases where inflammation had been identified, the acute phase proteins serum amyloid A and haptoglobin infection were associated with acute rather than chronic infection. This evidence from another species may explain the lack of significant results between the acute phase protein concentrations and pneumonia scores.

In addition, it is of note that the highest recorded values for haptoglobin were not associated with either type of pneumonia. There are two possible explanations for this,

the first being that haptoglobin concentration can be overestimated in samples due to the nature of the spectrophotometric assay (Heergaard *et al.*, 1998). The second explanation is that disease conditions other than those indicated by the respiratory lesions examined in this study were responsible for raised levels of this acute phase protein. Apart from infection with *Actinobacillus pleuropneumoniae* (Hall *et al.*, 1992) and pathological signs of enzootic pneumonia (findings of the current study), other infections reported to increase serum haptoglobin concentration are *Bordetella bronchiseptica* and *Pasteurella multocida* (van Miert, 1996), *Mycoplasma hyorhinis* (Magnusson *et al.*, 1999) and *Toxoplasma gondii* (Jungerson *et al.*, 1999). Although it is possible that some of the pigs may have been suffering from these conditions it is more likely that there are diseases other than those already reported, such as septicaemia arising from severe tail biting, that would cause the high levels of serum haptoglobin concentration (over 8.5 mg.ml<sup>-1</sup>) observed in this study. This suggests that haptoglobin should be regarded more of a general than specific disease health marker before further clinical or pathological inspection is carried out on any given herd.

The presence of free haemoglobin in a sample, for example through haemolysis, can result in a false negative result in the estimation of serum haptoglobin concentration (Eckersall *et al.*, 1996). It is of note that very little haemolysis was detected in any of the samples collected in the current study, following centrifugation. This shows that there was very little damage to the red blood cells within the sample. This may suggest that an optimal point for the collection of blood to be used in this particular assay is at the point of exsanguination during the slaughter process.

#### 7.5.2.2 Major Acute Phase protein

The induction of MAP in the pig by deliberate infection with *Actinobacillus pleuropneumoniae* has been reported to raise serum concentration from around 0.5 mg.ml<sup>-1</sup> to over 6.0 mg.ml<sup>-1</sup> (Heergaard *et al.*, 1998). Serum MAP concentration was raised to over 8 mg.ml<sup>-1</sup> following acute inflammation resulting from an injection with turpentine (Gonzales-Ramon *et al.*, 1995). The results of these previous reports support the current findings that serum MAP concentration varied between 0.23 and 6.5 mg.ml<sup>-1</sup>. However, no significant relationship was found between this acute phase protein and either of the respiratory lesion scores. This was probably due to variation in this particular protein due to conditions not measured in this study as suggested in section 7.4.2.1. The fact that MAP did not yield a significant result when haptoglobin did adds weight to the argument that acute phase proteins should be assessed together as part of an index and not in isolation, as suggested by Toussaint *et al.* (1995).

#### 7.5.2.3 Serum Amyloid A

There is little information describing actual values for SAA serum concentration in healthy or diseased pigs, although it has positively been identified as a positive acute phase protein (Heergaard *et al.*, 1998). The minimum value recorded in the current study was 2.2 µg.ml<sup>-1</sup> and the maximum 834.6 µg.ml<sup>-1</sup>. Therefore, although not found in the greatest concentration SAA was by far the biggest responder by over one hundred fold if the median value can be considered to be a “normal” level.

#### 7.5.2.4 C-reactive protein:

Burger *et al.* (1992) found normal levels of serum CRP concentration at  $<15\mu\text{g.ml}^{-1}$  in healthy commercially-reared pigs and up to  $90\mu\text{g.ml}^{-1}$  in pigs with disease. Serum CRP concentration in the pig has been reported to increase by a magnitude of around 7 times (from a normal level of  $45\mu\text{g.ml}^{-1}$  to a maximum of  $310\mu\text{g.ml}^{-1}$ ) with *Actinobacillus pleuropneumoniae* infection (Heergaard *et al.*, 1998). The minimum C-reactive protein serum concentration in the current study was  $19.7\mu\text{g.ml}^{-1}$  and the maximum was  $437\mu\text{g.ml}^{-1}$ , which are similar to those previous reports listed above. This, again, shows that there was considerable variation in the health status of the pigs in the current study. However, there was no significant relationship between this acute phase protein and either of the measured respiratory lesion scores.

#### 7.5.2.5 Albumin

Albumin is considered to be a negative acute phase protein and has been shown to be reduced in pigs subjected to transport and slaughter (Elbers *et al.*, 1991). Therefore, it is possible that any variation due to respiratory disease may have been masked and so explaining the non-significance of this result. This may also be true of the other acute phase proteins measured in this study, although there are no current reports as to the effects of transport, lairage and slaughter on these variables. There was a lot of variation in the range of albumin concentration in the blood samples between  $23.9\text{ mg.ml}^{-1}$  and the maximum of  $46.0\text{ mg.ml}^{-1}$ .

#### 7.5.2.6 Total Protein

Total protein has also been shown to be reduced in pigs subjected to transport and slaughter (Elbers *et al.*, 1991) which may have affected any differences that might exist between the groups identified for their differing states of respiratory lesions. There was some variation in the range of total protein concentration in the blood samples between 60.7 mg.ml<sup>-1</sup> and the maximum of 96.4 mg.ml<sup>-1</sup>.

#### 7.5.3 *Enzootic and Pleuro-pneumonia multiple regression models*

It is very important when considering methods of reducing respiratory problems to identify risk factors within farming systems that predispose pigs to these diseases (Stark *et al.*, 1998). At present, there is little quantitative evidence of the importance of these factors (Done, 1991). The use of these multiple regression models aids the identification of factors associated with respiratory disease and also allows the implementation of these factors in predictive equations that could be used on other farms to estimate prevalence of enzootic or pleuro-pneumonia. However, certain limitations must still be recognised. The 17 farms in this study show variation in their farming systems, but cannot realistically model all farming practices in the UK, allowing only limited extrapolation to other commercial units in other areas. The time of year has been identified as a major factor in mediating respiratory disease (Stark *et al.*, 1998). However, this study only took place over the summer period when pneumonia prevalence can be expected to be reduced and so this must also be considered when interpreting and in the further application of these results. It is also likely that the pigs in each delivery had been previously housed in the same pen or a few pens. Since respiratory disease can easily be communicated between animals in the same pen



(Jorgenson, 1992) it was probable that the occurrence of either pneumonia type would have been clustered within these pens and perhaps not a fair representation of the each farm, although each delivery would be the majority of a particular age group passing through the farm system.

#### 7.5.3.1 Enzootic pneumonia scores:

Both of the multiple regression equations concerning enzootic pneumonia were significant but only contained a single term, explaining approximately 22% of the variation of the farm means of this type of lesion in this study. The use of fan-assisted ventilation in the grower accommodation was associated with an increase in pathological signs of enzootic pneumonia. A previous study reported that an air exchange rate of  $>60\text{m}^3$  per hour per pig had a protective effect on the prevalence of pneumonia (Flesja *et al.*, 1982). Although ventilation rates were not determined in this study it is possible that those farms utilising fan-assisted ventilation did have lower ventilation rates than those that did not with the associated increase of aerosol levels of pathogens, dust and noxious gases. Dust and noxious gases can affect the protective cilia and mucous membranes of the respiratory tract reducing their capacity to cope with pathogenic infection (Christensen and Mousing, 1992). Mechanical ventilation resulting in increased air movement over a totally slatted floor can also lead to an increase in ammonia production (Cargill and Skirrow, 1997).

The finding that the number of cases positively identified for enzootic pneumonia out of the 30 samples per farm was associated with the individual treatment of finishers by

injection was an expected relationship. Increased respiratory disease in finishers is likely to lead to increased treatment using antibiotics to reduce the effects of infection and is reflected in the increased treatment of individuals by injection.

#### 7.5.3.2 Pleuropneumonia scores:

The multiple regression equations concerning signs of pleuropneumonia were both significant. The first concerning the farm mean for PL score although significant only contained a single term, explaining approximately 23 per cent of the variation. However, the second score reflecting the number of positively identified cases per farm contained three significant terms that explained nearly 78 per cent of the variation. Herd type has been previously identified as an influential risk factor for respiratory diseases in swine. Stark (2000) states that as breeding farms are less likely to buy large numbers of animals and from different sources they are less likely to suffer from respiratory infections than fattening farms due to reduced risk of introducing pathogenic organisms. There is also a reduced likelihood of naïve animals being exposed to infection either from positive animals entering a clean herd or naïve animals entering a positive herd. The current finding that breeder-finisher units were associated with reduced PL score in the multiple regression model compared with finisher-only units supports this statement, together with similar findings from other studies (Mousing, 1991; Hofer, 1993).

The presence of a slatted dunging area in the finisher accommodation was associated with an increase in the number of positive cases of pleuropneumonia identified per farm. This is supported by evidence from a previous study (section 3.5.2) that found a slatted dunging area of the finisher accommodation was associated with a higher cough score.

Other studies have had similar findings. Tuovinen *et al.* (1997) reported that the use of slatted pen floors was associated with increased signs of disease in finishing pigs, in general, while the use of a liquid manure system was reported to be associated with an increase in pleuropneumonia and/or pleuritis in grower pigs (Stark *et al.*, 1998) – both supporting the findings of the current study. Totally slatted floors can increase pig exposure to ammonia (Cargill and Skirrow, 1997). Exposure to low levels ammonia (35 ppm) for short periods can result in inflammatory changes in the wall of the respiratory tract, in addition to reducing bacterial clearance from the lungs (Johannsen *et al.*, 1987) thereby increasing susceptibility to respiratory disease.

The second term in the model states that fan-assisted ventilation is associated with a reduction in the number of cases of pleuropneumonia signs being identified per farm. This is contrary to the findings for the enzootic pneumonia model and may suggest that this form of ventilation is more important in the prevention of pleuropneumonia than enzootic pneumonia. An automatically controlled environment has been suggested to be advantageous for the respiratory health of growing pigs (Stark *et al.*, 1998), although was actually a risk factor for nursery pigs (Stark *et al.*, 1998). Flesja *et al.* (1982) reported that increased ventilation reduced the risk of pleuropneumonia infection, a result in agreement with those of the current study.

The use of wet/dry feeding in the nursery has been demonstrated to be associated with a reduction in the risk of enzootic pneumonia lesions seen at slaughter (Stark *et al.*, 1998). The reason suggested for this was reduced physical contact between pigs due to the nature of the feeding device. This suggestion is contrary to the finding of the present

study that the wet-feeding of finisher pigs was associated with an increase in the number of positive cases of pleuropneumonia per farm. It is most common for wet-fed pigs to eat simultaneously, which would increase contact between pigs and therefore increase the chance of transmitting diseases such as pneumonia.

#### *7.5.4 Acute Phase Protein and Total Protein multiple regression models*

Acute phase proteins can be considered to be general indicators of pig health (Holck *et al.*, 1998) and therefore factors found to be associated with increased levels (or decreased in the case of negative acute phase proteins, such as albumin) may be described as risk factors for disease. It is of note that although all the proteins, apart from total protein, measured in this study are sensitive to infection characterised by an acute phase response (Elbers *et al.*, 1991; Heergaard *et al.*, 1998), different variables were found to be the best predictors of each. This may demonstrate the different kinetics of the response of each, for example haptoglobin and MAP having a more prolonged response than CRP (Heergaard *et al.*, 1998). Another factor that must be taken into consideration is that the respiratory lesions examined would represent chronic and not acute infection as discussed above (section 7.4.2) and so the multiple regression models concerning the acute phase proteins should be considered separately

##### *7.5.4.1 Haptoglobin*

The use of solid partitions between individual pens of finisher pigs was associated with reduced mean serum haptoglobin concentration compared with pigs that were allowed physical contact between pens. It has been demonstrated that solid pen walls reduce the risk of infection between pens (Morris *et al.*, 1995) and that they are associated with

improved respiratory health at the farm level (Flesja *et al.*, 1982; Hurnik *et al.*, 1994). The current findings reflect the reduced risk of infection of diseases transmissible through physical contact that would result in an acute phase response. That this is the first term in the model emphasises the importance of this particular factor in the prevention of disease.

An increase in Finisher pen size was associated with a reduction in mean serum haptoglobin concentration. The importance of adequate pen size on a pig's health and welfare is well known (Edwards *et al.*, 1988). A reduced pen area to below 0.7m<sup>2</sup> per pig has been reported to greatly increase the risk of respiratory disease (Lindquist, 1974), although pen size and not space allocation was the significant term in this model. As the minimum pen size in this study was 13.3 m<sup>2</sup> and the maximum 100.0 m<sup>2</sup> this translates, according to the regression equation presented in table 7.8, to a significant difference of 0.51 mg.ml<sup>-1</sup> serum haptoglobin concentration. Although not a large difference, this level of increase is now considered to be a positive acute phase response (Heergaard *et al.*, 1998). There are a number of mechanisms by which increased space might reduce the acute phase response. The increased space and corresponding air volume will reduce the concentration of infectious agents found as airborne or non-airborne particles (Stark, 2000). The associated reduction in pig contact may also reduce cross-infection and possible stress due to social interaction. Stress resulting in the production of cortisol that has been demonstrated to influence the ability of a pig to cope with pathogenic infection (Johnson *et al.*, 1994; Wallgren *et al.*, 1994b) affecting the risk of an acute phase response occurring.

#### 7.5.4.2 MAP

An increase in mean serum MAP concentration was associated with the provision of straw bedding material to grower pigs. The use of bedding was a risk factor for nursery but not grower pigs in a previous report (Stark *et al.*, 1998) and the use of straw bedding in the grower accommodation was associated with a reduction in finisher clinical signs of respiratory disease (section 3.5.2). Therefore, this result is difficult to explain in causative terms.

The second term in the MAP model indicates that increased MAP is associated with fan-assisted ventilation in finisher accommodation compared with natural ventilation. This is in line with increases seen also in the enzootic pneumonia model (section 7.4.3.1) but contrary to the findings of the PL score model (section 7.4.3.2), perhaps suggesting that the EP score was more representative of recent infection than the PL score.

Increased MAP was associated with the individual treatment of respiratory disease in finishers by injection. Although no significant relationship was found between MAP and EP score, again the two models share the same term indicating that some sort of interaction exists between them.

#### 7.5.4.3 Serum Amyloid A

Increased SAA was also associated with the individual treatment of respiratory disease by injection, only this time in growers. The utilisation of direct treatment implies that clinical signs of respiratory disease were present indicating a reduced level of herd

health. This may have persisted to slaughter weight resulting in the elevation of serum concentrations of this particular acute phase protein.

#### 7.5.4.4 C-reactive protein

Increased CRP was associated with the occurrence of finisher pigs sharing a room with stock that was at least 5 weeks younger. This has previously been identified as a risk factor for respiratory disease (Hurnik *et al.*, 1994; Stark *et al.*, 1998) and is likely to be a risk factor for all contagious diseases due to naïve animals coming into contact with others carrying infection.

An increase in mean CRP serum concentration was associated with the finisher pigs not being given ad libitum access to water. Again, this is a risk factor for respiratory disease (Tuovinen *et al.*, 1997) and suggests the merits of CRP as an additional indicator of general health. A reduction in water intake may desiccate the mucous membranes of the respiratory tract and therefore reduces pathogen clearance (Christensen and Mousing, 1992).

The reduction in mean CRP concentration associated with vaccination against enzootic pneumonia suggests that this form of preventative medicine is successful in reducing respiratory disease and/or is associated with good management on these commercial units.

#### 7.5.4.5 Albumin:

Decreased mean albumin concentration was associated with the daily removal of growers effluent. Pig effluent is the main source of ammonia and high levels of ammonia is an indicator of poor effluent disposal (Cargill and Skirrow, 1997). However storing effluent for up to 4 weeks can reduce ammonia evaporation (Cargill and Skirrow, 1997) suggesting that regular emptying of the slurry pit might lead to increased ammonia production. This is supported by evidence from another study that a high frequency of manure removal was reported to increase the risk of enzootic pneumonia (Stark *et al.*, 1998). The current results appear to support these previous findings as a reduction in albumin as a negative acute phase protein indicates some form of disease present, although the underlying mechanism it is still unclear. Therefore in this study the removal of slurry may be associated with a release of noxious gases, such as ammonia or hydrogen sulphide that can have damaging effects on the cilia of the respiratory tract (Christensen and Mousing, 1992) increasing the risk of respiratory infection.

The increase in mean albumin concentration associated with vaccination against enzootic pneumonia is similar to that result found for CRP (section 7.4.4.4).

#### 7.5.4.6 Total protein:

As discussed in section 7.4.2.6 the transport and lairage process has a significant effect on total protein concentration (Elbers *et al.*, 1991). Therefore, when measured in blood taken at slaughter this variable may not be of use when considering the effects of environment on pig health.



## 7.6 Conclusions

The current findings indicate that there are components of the farm environment that influence the variation in the prevalence of signs of respiratory disease measured at slaughter and levels of serum acute phase proteins. The levels of pneumonia found in this study are in agreement with those previously reported in the UK (Done, 1991). There has not been a previous study assessing the levels of acute phase proteins in commercial pig herds in the UK but the levels of acute phase proteins are consistent with those previously reported in controlled trials with *Actinobacillus pleuropneumoniae* (Heergaard *et al.*, 1998). It is suggested that although haptoglobin is a useful indicator of enzootic pneumonia (infection with *Mycoplasma hyopneumoniae*), the level of variation, presumably from other inflammatory conditions, means that these acute phase proteins are more useful as general indicators of health rather than specific to respiratory conditions in a general survey. The method of scoring for possible pleuropneumonia (PL score) was not successful in differentiating animals showing an acute phase response and may not be an appropriate measure of this disease at slaughter. However, this scoring system may still be of use in assessing the prevalence of pleuropneumonia during rearing.

Multiple regression models were successfully created for both pneumonia scores and all the measured proteins, excepting total protein. They all showed significant predictive powers with  $r^2$  varying from 0.22 to 0.77. Beskow *et al.*, (1998) reported that there was no association between environmental parameters (temperature, humidity and noxious

gases) and prevalences of pneumonia and pleuritis at slaughter. The current study also did not find any significant relationships between these factors and respiratory diseases but did find a number of others that showed important associations. Measures of enzootic pneumonia were not related to well known risk factors for this disease (Stark, 2000). The use of fan-assisted ventilation or individual treatment of finishers by injection explained considerable variation without any other known risk factors, highlighting important associations for further research. Pleuropneumonia score and the number of positive cases per farm were related to known risk factors and this study indicates their relative importance.

As predicted, the models of the acute phase proteins showed significant associations with known risk factors for disease including physical contact between pens, the need for individual treatment of pigs by injection, pigs housed on a continuous basis rather than batched/ all-in all-out, restricted access to water and irregular removal of effluent/manure. Other factors identified as being associated with increased serum acute phase protein levels included the use of bedding for growers and the use of fan-assisted ventilation for finishers, the latter also being unexpectedly identified as a risk factor for EP score.

## **CHAPTER 8. AN INVESTIGATION TO DETERMINE WHETHER ENRICHING THE ENVIRONMENT OF A YOUNG PIG AT PARTICULAR STAGES OF DEVELOPMENT INCREASES ITS ABILITY TO COPE WITH STRESSORS.**

### **8.1 Introduction**

Broom (1986) defined the welfare of an individual as “its state with regard to its attempts to cope with its environment”. Rearing in an enriched environment has been suggested to improve the ability of pigs to cope with subsequent stressors (Pearce *et al.*, 1989) and therefore its welfare according to the definition given above. It is possible that this may be more important during certain “plastic” periods during the animal’s psychological development. The use of a substrate, such as unchopped straw, has been suggested to be a suitable source of enrichment by providing the pig with an object for its endogenous motivation to explore (Wood-Gush and Vestergaard, 1991). However, a number of studies in this area have confounded the possible benefits to pig welfare of environmental enrichment using a substrate and increased space allowance (Beattie *et al.*, 1995a, 1995b; 1995c, 1996; De Jong *et al.*, 1998). Space allowance during rearing has been shown to have profound effects on subsequent behaviour (Schouten, 1986) and immune competence (Turner *et al.*, 2000).

Previous work has shown that enriching the environment during certain rearing periods reduced harmful social behaviours and that previous experience of either a barren or enriched environment affected later behaviour (Beattie *et al.*, 1995b). What is not clear is whether this change in behaviour was important in mediating the pigs’ ability to cope with stressors. Evidence from another study suggests that environmental enrichment does not influence the physiological response of pigs as determined by heart rate,

temperature and cortisol measures to certain stressors (relocation, isolation and restraint) (De Jong *et al.*, 1998). However, this study did report increased salivary cortisol concentrations in pigs kept in enriched rather than barren conditions. Wallgren *et al.* (1994b) demonstrated that cortisol production resulted in inhibition of antibody production and a significant increase in the neutrophil:lymphocyte ratio. This means that stressors resulting in a cortisol response may have an effect on the immune response of a pig. However, a subsequent study found no effect of an enriched environment on immune function (De Groot *et al.*, 2000), even though they did confirm previous reports of increased baseline cortisol concentrations in enriched compared with barren housed pigs.

Earlier evidence from this project suggests that the provision of straw bedding over a certain rearing period was important in influencing behavioural and physiological welfare parameters, despite these contrary reports (De Jong *et al.*, 1998; De Groot *et al.*, 2000). These included effects on subsequent human approach behaviour (section 2.5.2) and unloading time after transport (section 4.5.2). The use of straw bedding at the grower stage was also associated with reduced lesions in lairage (section 4.5.4) and reduced acute phase response (indicated by serum MAP concentration, section 7.5.4.2). The prevalence of gastric ulcers at slaughter was also significantly affected by the presence of a straw bedded lying area in the finisher accommodation (section 6.5.2).

This experiment was designed to investigate the effects of enriching the environment of a growing pig by simply providing access to unchopped straw at particular stages of development on its subsequent ability to cope with exposure to stressors as determined

by standard measures of welfare. Effects on the pig's immune and endocrine systems were also assessed.

## 8.2 Materials and Methods

The study was carried out as two replicates, each over a 16-week period, which was divided into 3 stages that represent typical management practices:

Stage 1 = 0-4 weeks

Stage 2 = 5-9 weeks

Stage 3 = 10-16 weeks

In each replicate there were five treatments. Each treatment was provided with straw bedding at either one of the three stages, at each stage or not at all. The treatment codes and imposed treatments are presented in table 8.1.

**Table 8.1. Treatments and treatment codes for environmental enrichment stages.**

Treatment code	Stage 1 (0-4 weeks)	Stage 2 (5-9 weeks)	Stage 3 (10-16 weeks)
BBB	Barren	Barren	Barren
EBB	Enriched	Barren	Barren
BEB	Barren	Enriched	Barren
BBE	Barren	Barren	Enriched
EEE	Enriched	Enriched	Enriched

### *8.2.1 Animals and Housing*

Cross fostering was kept to minimum and was carried out in the first 24 hours after birth. Each piglet was teeth clipped and given an iron injection. All pigs were given ear tags at weaning for identification purposes.

#### Stage one

Eight sows were designated as being either on the Barren or Enriched treatment, four per treatment. Sows producing a litter designated as barren conditions for this stage farrowed in standard farrowing crates and remained there with their litters until the end of the stage. Sows with litters designated as being kept in the enriched conditions farrowed in standard farrowing crates but 0.5 kg of straw was added to the creep area on each weekday, after the removal of any residual straw from the previous day.

#### Stage two (12 pigs)

Stages two and three both took place in an experimental pig rearing facility (see figure 8.1). Pigs were assigned to treatments EBB and EEE from those four litters reared under enriched conditions at stage one and were balanced for sex, weight and litter of origin. Pigs were assigned to treatments BBB, BBE and BEB from those four litters reared under barren conditions at stage one and were also balanced for sex, weight and litter of origin. The groups subjected to barren conditions were kept in a pen with solid sides to the floor measuring 3 x 2m (space allowance = 0.5m<sup>2</sup>/animal), on a concrete floor until the end of the stage. Groups provided with enriched conditions were kept in a similar sized pen with a concrete floor covered with unchopped straw bedding. Each of the

enriched pens was provided with 0.5 kg fresh straw once a day after being cleaned (only dirty bedding material removed).

### Stage three (nine pigs)

The pigs remained in the same pens as stage two and were subjected to the same management regimes according to their designated environment. Three pigs were removed from each treatment group (the fourth, fifth and sixth heaviest). Space allowance was 0.75m<sup>2</sup>/animal) during this stage.

#### *8.2.2 Daily liveweight gain and food conversion*

At the end of each stage all the pigs were weighed. Food intake was measured on a pen basis and averaged out for each pig to give a food conversion value.

#### *8.2.3 Skin lesion scoring*

All pigs were examined after each stage at weighing for skin lesions according to the method described in section 3.2.2.2.

#### *8.2.4 Open Field, Novel Object and Human Approach Tests*

The open field, novel object and human approach tests were carried out in week 13 over a two-day period. The pigs were randomly taken one at a time from each treatment in turn until all pigs had been tested to minimise any variance due to time of day.

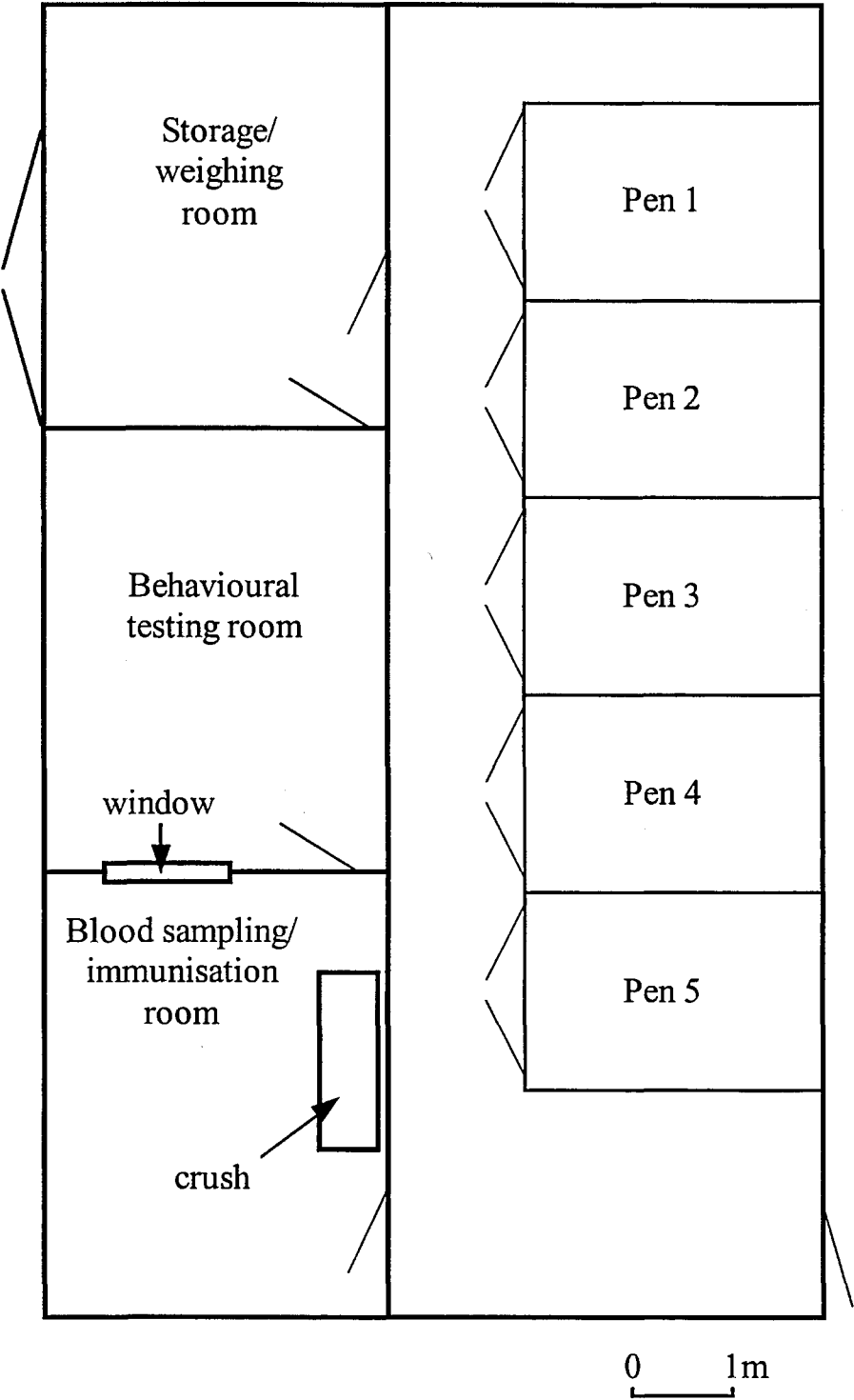
Isolation and exposure to novelty are both potential stressors of the pig and were assessed using the following methodology. Using an open-field test based on that described by Varley and Stedman (1994) each pig was given a 3 minute open field test in an arena (an individually ventilated room measuring 4.5 x 3.5 m<sup>2</sup>) which had been divided into 4 x 4 squares. The number of squares entered (differentiating between peripheral and central squares, number of vocalisations (grunts and squeals), defecations and urinations were recorded.

Immediately following the open field was a novel object test and a human approach test as described by Pearce *et al.* (1989):

The novel object test was carried out by lowering an orange plastic bucket to the floor in the centre of the arena. During the next 3 minutes each pig was observed for 1. latency to approach 0.5m from the novel object; 2. total time spent within 0.5m of the novel object; 3. latency to first physically interact with the novel object; 4. total time interacting with the novel object; 5. the number of interactions with the novel object (one interaction recorded as lasting up to 3 seconds).

Immediately following the removal of the novel object, a human subject dressed in white overalls and boots entered the test arena and stood erect against one wall of the testing area. During the next 3 minutes the pig were observed for: 1. latency to approach 0.5m from the human; 2. total time spent within 0.5m of the human; 3. latency to first physically interact with the human; 4. the number of interactions with the human (one interaction recorded as lasting up to 3 seconds).





**Figure 8.1 A scale diagram of the experimental pig rearing facility, showing pen layout and behavioural testing room**

### 8.2.5 Immune challenge

At 13 weeks of age following the behavioural testing, all the pigs in each treatment group were immunised with 1 mg keyhole limpet haemocyanin (KLH) / alum injected intramuscularly in the neck. Blood samples of 10 ml were collected by jugular vein puncture using evacuated glass tubes. One sample was taken on days 0 and seven following immunisation and one on day 21. Serum was stored at -20 C until analysis. Anti-KLH antibody levels were analysed by a direct ELISA method based on the method of Mackenzie (1994).

### 8.2.6 ACTH challenge

Jensen *et al.* (1995a) showed that intermittent stress (unpredictable, inescapable electric shocks) resulted in significant increased adrenocortical reactivity to ACTH stimulation in growing pigs, therefore demonstrating the use of an increased response to an ACTH challenge as an indicator of chronic stress. To determine whether the pigs in each treatment varied in how they coped with their rearing conditions they were subjected to an ACTH challenge at 16 weeks of age (day 21 after immunisation with KLH) according to the following methodology: As described above, pigs were blood sampled using vacuum tubes. Immediately after, they were injected intramuscularly with 25 i.u. of ACTH (ACTH<sub>1-24</sub>, Synacthen®, Ciba-Geigy, Basle, Switzerland) to test the capacity of the adrenal cortex under maximal stimulation.. Blood samples were taken immediately prior to ACTH injection and 60 minutes afterwards. These samples were then centrifuged immediately and then stored at -20°C until subsequently analysed using a radio-immunoassay. Serum cortisol levels were analysed using a radioimmunoassay technique (Bayer Corporation - Publication No. DA4-1174L95).

### 8.3 Statistical analysis

Data were checked for normal distribution and homogeneity of variances. Means and standard errors were calculated for weights (at individual pig level) and food conversion ratios (at pen level) but there was not enough data for further statistical analysis. Differences between treatment means for the KLH data and the ACTH data were carried out by analysis of variance using replicate as a blocking factor. Parametric behavioural data were also analysed by analysis of variance (transformed according to equation  $y = \log_e(x+1)$  if necessary) using replicate as a blocking factor, while non-parametric data were analysed using the Kruskal-Wallis method. Spearman rank order correlation coefficients were used to determine whether there was any consistence between response to the open-field, novel object and human approach tests and physiological data. All statistical analysis was performed using the Genstat for Windows statistics package (Genstat V, 1995).

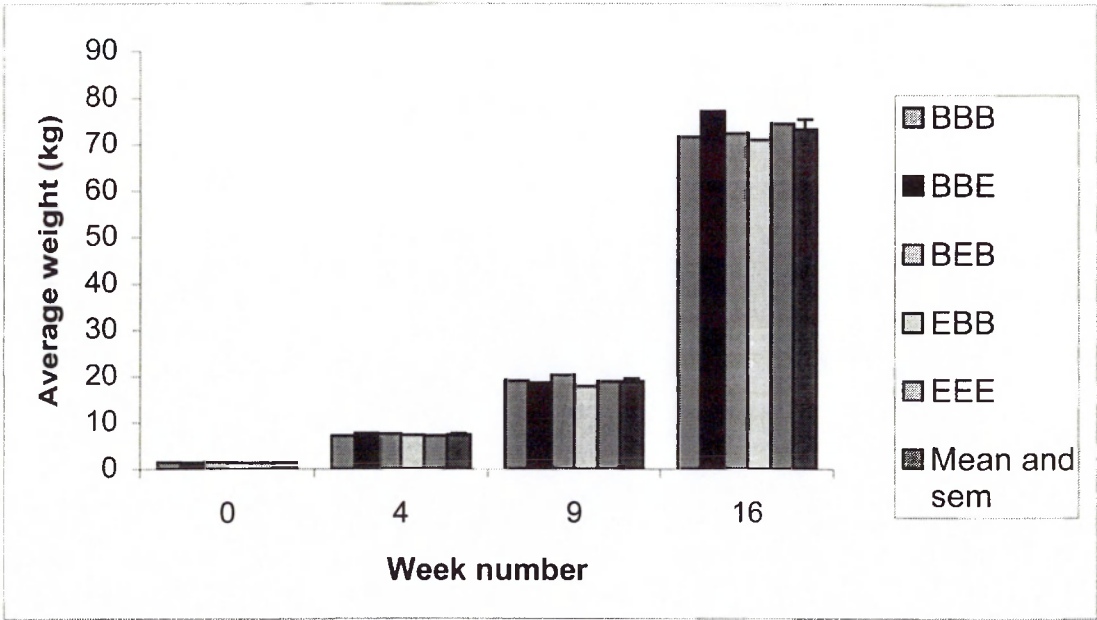
## 8.4 Results

### *8.4.1 Average weight gain and feed conversion ratios*

Mean weight gain per day for all the pigs over both replicates was  $654.6 \pm 8.54 \text{ g.day}^{-1}$  (individual treatment means and standard errors shown in table 8.2). Mean food conversion ratios were  $1.3 \pm 0.04$  and  $1.6 \pm 0.06$  for stages two and three, respectively (individual treatment means and standard errors shown in table 8.3).

There were significant positive relationships between birth weight and weaning weight ( $r=0.48$ ,  $p<0.001$ ) and weight at the end of stage two ( $r=0.42$ ,  $p<0.001$ ).

In replicate one, one animal was removed from treatment EEE at stage two (due to a broken leg) and in both replicates an animal was removed from treatment BEB at stage three (each due to a prolapsed rectum).



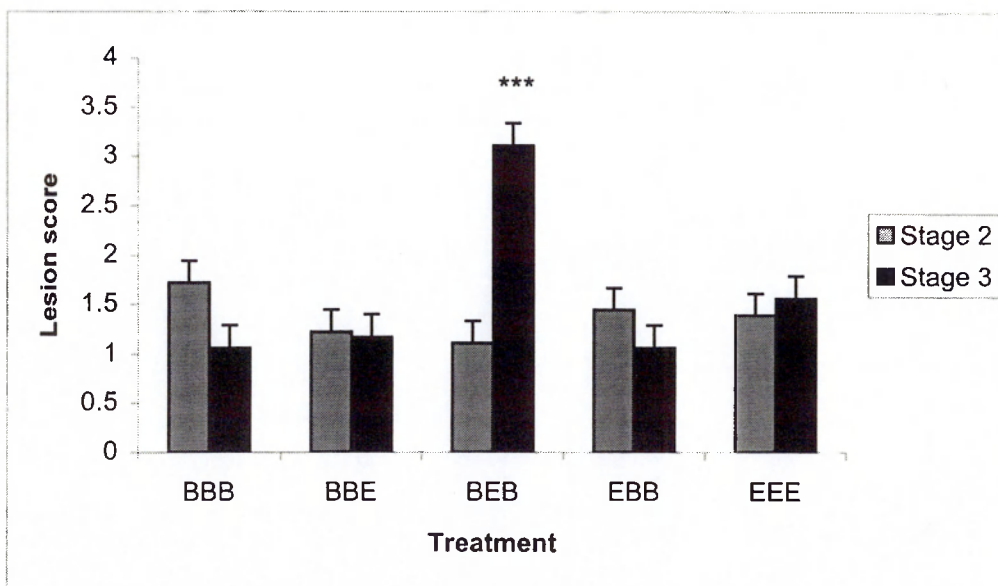
**Figure 8.2** Effect of rearing environment on average weights for each treatment at birth and at the end of stages one, two and three.

**Table 8.2** Effect of rearing environment on mean weight gain of pigs from 0-16 weeks.

Treatment	Mean (g.day <sup>-1</sup> )	sem
BBB	639.1	23.8
BBE	688.7	17.2
BEB	646.0	14.9
EBB	633.6	20.2
EEE	664.6	15.6

**Table 8.3** Effect of rearing environment on food conversion gain of pigs from 5-8 and 9-16 weeks.

Treatment	Stage two ± sem.	Stage three ± sem
BBB	1.2±0.07	1.5±0.09
BBE	1.2±0.07	1.4±0.01
BEB	1.2±0.09	1.5±0.06
EBB	1.2±0.16	1.6±0.21
EEE	1.2±0.06	1.6±0.07



**Figure 8.3** Effect of rearing environment on lesion scores after stages two and three (means and standard errors shown, \*\*\* indicates  $p < 0.001$ ).

#### 8.4.2 Lesion scores

Only three pigs in each replicate showed any lesions after stage one (in replicate one, two from the EBB treatment and 1 from the BBE treatment; in replicate two, one from the EBB treatment, one from the BBB treatment and one from the EEE treatment). There were no significant differences between treatment in lesion scores measured after stage two (treatment means shown in figure 8.3). There was a significant increase in lesion score after stage three in the pigs on treatment BEB ( $p < 0.001$ ) compared with the other four treatments (treatment means shown in figure 8.3). There was no significant difference in the location of the skin lesions.

**Table 8.4 Results of the analysis of variance for the parametric data from the open-field, novel object and human approach tests.**

Treatment:		BBB	BBE	BEB	EBB	EEE	sem
OFT	total ambulation score	40.1	45.1	39.3	36.4	37.4	4.14
	<i>peripheral squares</i>	33.0	35.7	33.0	30.5	28.7	3.37
	<i>centre squares</i>	7.1	9.4	6.3	5.8	8.7	1.25
NO	latency to 0.5m (s)	21.7	7.9	19.0	12.9	15.5	0.278 <sup>†</sup>
	latency to 1st contact (s)	26.0	16.4	30.8	29.2	22.6	0.272 <sup>†</sup>
	no. interactions	3.6	5.1	4.4	4.0	4.4	0.45
	total interaction time (s)	28.2	26.7	43.7	34.4	43.9	7.19
	average interaction time (s)	8.8	5.7	9.9	9.5	9.5	1.67
HA	latency to 0.5m (s)	64.8	32.0	45.7	49.9	69.3	0.369 <sup>†</sup>
	latency to 1st contact (s)	87.0	34.4	68.8	70.4	75.9	0.344 <sup>†</sup>
	no. interactions	11.2	9.5	11.7	11.7	7.4	2.43
	total interaction time (s)	1.7	2.5	2.1	1.8	2.0	0.34
	average interaction time (s)	23.9	22.7	237	21.7	19.0	4.27

<sup>†</sup> sem taken from transformed data according to equation  $y=\log_e(x+1)$

**Table 8.5 Results of the analysis of variance by the Kruskal-Wallis method for the non-parametric data from the open-field test.**

OFT		BBB	BBE	BEB	EBB	EEE
No. grunts	Median	34.5	41	35.25	57.5	46.5
	Minimum	0	0	0	0	0
	Maximum	123	144	120	127.5	153
	Mean Ranks	43.5	42.9	48.7	46.3	46.1
No. squeals	Median	0	0	0	0.5	0
	Minimum	0	0	0	0	0
	Maximum	3	27	3	34	33
	Mean Ranks	40.5	45.1	48.8	49.1	44
No. defecations	Median	1	1	1	1	1
	Minimum	0	0	0	0	0
	Maximum	2	5	4	3	3
	Mean Ranks	44	42.4	41.9	53.7	45.5
No. urinations	Median	0	0	0	0	0
	Minimum	0	0	0	0	0
	Maximum	1	1	1	1	0
	Mean Ranks	46.4	46.6	46.4	46.6	41.5

**Table 8.6 Results of the analysis of variance by the Kruskal-Wallis method for the non-parametric data from the novel object test.**

<b>NO test</b>		<b>BBB</b>	<b>BBE</b>	<b>BEB</b>	<b>EBB</b>	<b>EEE</b>
No. defecations	Median	1	1	1	1	1
	Minimum	0	0	0	0	0
	Maximum	3	2	2	2	3
	Mean Ranks	54.1	44.5	32.7	48.5	47.7
No. urinations	Median	0	0	0	0	0
	Minimum	0	0	0	0	0
	Maximum	1	1	1	1	1
	Mean Ranks	46.3	46.7	43.7	41.6	49.2

**Table 8.7 Results of the analysis of variance by the Kruskal-Wallis method for the non-parametric data from the human approach test.**

<b>HA test</b>		<b>BBB</b>	<b>BBE</b>	<b>BEB</b>	<b>EBB</b>	<b>EEE</b>
No. defecations	Median	1	1	0.5	1	1
	Minimum	0	0	0	0	0
	Maximum	2	3	2	2	2
	Mean Ranks	54.4	52.6	41.1	37.1	42.3
No. urinations	Median	0	0	0	0	0
	Minimum	0	0	0	0	0
	Maximum	1	1	1	1	1
	Mean Ranks	44.2	42.1	54.4	39.6	47.2



**Table 8.8 Spearman rank order correlation coefficients between measures of response to the open-field test (OFT), novel object test (NO) and the human approach test (HA).**

	OFT ambulation score	OFT no. grunts	NO latency to 1 <sup>st</sup> contact	NO no. interactions	HA latency to 1 <sup>st</sup> contact	HA no. interactions
OFT ambulation score	1					
OFT no. grunts	0.22***	1				
NO latency to 1 <sup>st</sup> contact	-0.53***	0.26**	1			
NO no. interactions	0.355***	0.08	-0.411***	1		
HA latency to 1 <sup>st</sup> contact	-0.411***	0.31***	0.577***	-0.334***	1	
HA no. interactions	0.328***	0.22*	-0.408***	0.368***	-0.7***	1

\*, \*\*, \*\*\* indicate  $p < 0.05$ ,  $p < 0.01$  and  $p < 0.001$ , respectively

#### 8.4.3 Behavioural testing

There were no significant differences between treatments for any of the measures taken from the open field, novel object or human approach tests (treatment means shown in tables 8.4, 8.5, 8.6 and 8.7). There were highly significant Spearman rank order correlations between ambulation score and number of grunts in the open- field test, latency to first contact in the novel object test, number of interactions in the novel object test, latency to first contact in the human approach test and number of interactions in the human approach test (correlation coefficients presented in table 8.8). Those animals with high ambulation scores were significantly more likely to have low approach latencies in both the novel object ( $p < 0.001$ ) and the human approach tests ( $p < 0.001$ ). Animals with low approach latencies were significantly more likely to have a higher number of interactions with either the novel object ( $p < 0.001$ ) or the human subject ( $p < 0.001$ ). There were no significant relationships between measures of behaviour and any physiological data. All statistical analysis was carried out using Genstat for Windows statistical software (Genstat V, 1995).

**Table 8.9 Effect of rearing environment on anti-KLH IgG levels and plasma cortisol levels.**

		BBB	BBE	BEB	EBB	EEE	sem
KLH (OD <sub>405</sub> )	day 0	0.055	0.063	0.072	0.075	0.052	0.0080
	day 7	0.316	0.285	0.350	0.333	0.306	0.0180
	day 21	0.445	0.417	0.452	0.435	0.427	0.0232
Cortisol (nmol.l <sup>-1</sup> )	0 min (basal)	359	318	304	263	291	44.1
	60 min	482	644	577	562	609	61.1
	difference	156	325	260	308	337	81.0

#### 8.4.4 KLH immune response

Although there were no significant differences due to treatment for the anti-KLH IgG levels (table 8.9), there were significant differences between the two replicates, as shown in figure 8.4 (replicate means were significantly lower in the first replicate compared to the second at day 0, 7 and 21,  $p < 0.001$ ).

#### 8.4.5 ACTH challenge response

There were no significant differences between treatment means for basal cortisol levels or the cortisol response to the ACTH challenge test (treatment means and standard errors shown in table 8.9). There were significant replicate differences in the cortisol data (figure 8.5). Replicate means were significantly lower in the first replicate compared to the second in the sample taken immediately prior to the ACTH challenge ( $p < 0.001$ ). This was repeated in the difference measured between 0 and 60 minutes (difference in serum cortisol concentration between immediately prior to ACTH challenge and 60 minutes later for replicates 1 and 2, respectively was 473 vs. 81 nmol.l<sup>-1</sup>,  $p < 0.001$ ).

#### *8.4.6 Individual replicate analysis for KLH data or the serum cortisol data*

Due to significant differences between replicates in the anti-KLH IgG levels and the serum cortisol concentrations the data were reanalysed for each replicate separately. However, there were still no significant differences due to treatment for either the anti-KLH IgG levels or the serum cortisol concentrations.

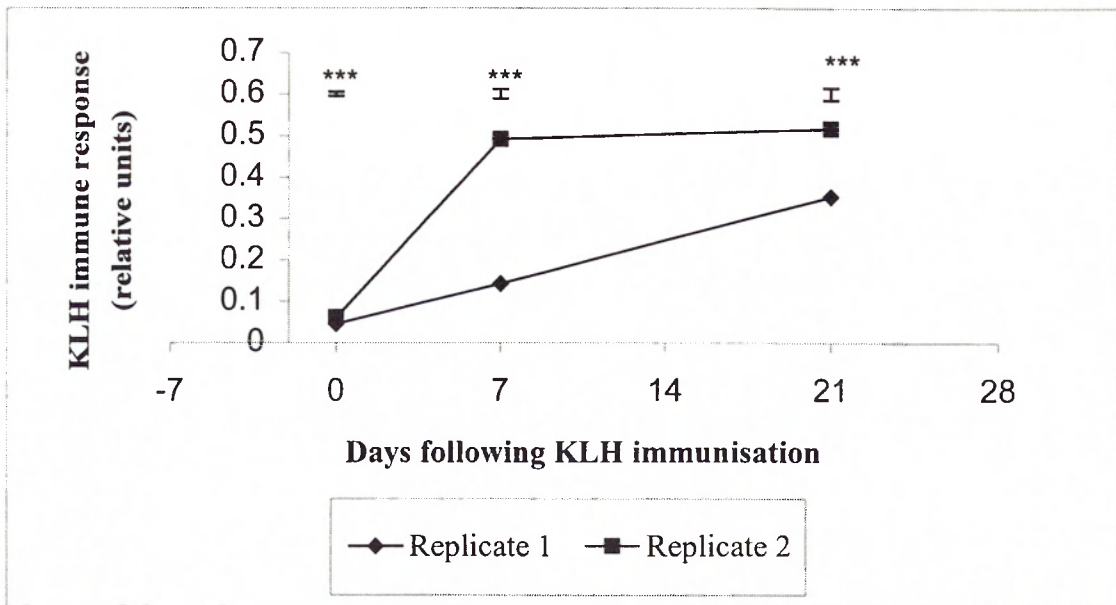


Figure 8.4 Significant differences between replicates 1 and 2 in the anti-KLH IgG levels (\*\*\*) indicates  $p < 0.001$ , standard error bars shown).

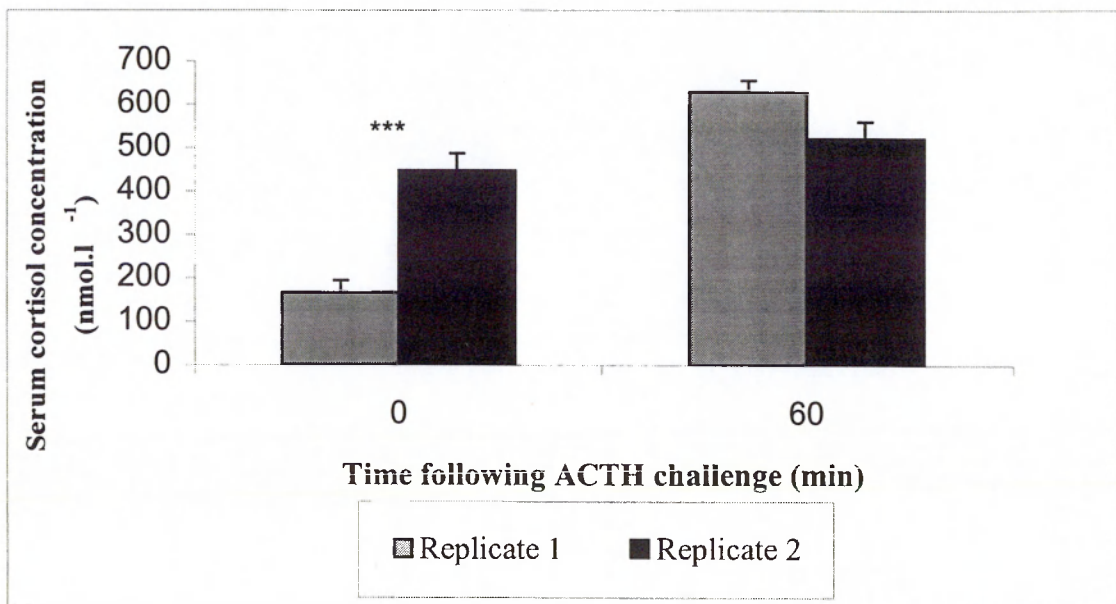


Figure 8.5 Significant differences between replicates 1 and 2 in the serum cortisol concentrations (\*\*\*) indicates  $p < 0.001$ , standard error bars shown).

## 8.5 Discussion

The results of this experiment demonstrate that rearing an environment enriched simply by the provision of unchopped straw at various stages did not influence the immune function, adrenal cortisol response to an ACTH challenge or the behaviour of pigs undergoing an open field test, novel object test or human approach test. However, the removal of straw after providing it between the ages of five to eight weeks was associated with a significant increase in skin lesions compared to pigs on the other treatments.

There are a great number of studies that demonstrate the significant influence that environmental enrichment during rearing has on subsequent pig behaviour (e.g. Beattie *et al.*, 1995a, 1996; De Jonge *et al.*, 1996; O'Connell and Beattie, 1999; Olsson *et al.*, 1999; Pearce *et al.*, 1989; Pearce and Paterson, 1993; Petersen *et al.*, 1995; Schouten, 1986). When presented with a novel object test, pigs reared in a barren environment have previously been shown to interact more quickly with the object (De Jong *et al.*, 1998; Olsson *et al.*, 1999; Pearce *et al.*, 1993) than those reared under more enriched conditions, suggesting a greater motivation to explore the environment. Evidence from the current study suggests that the provision of unchopped straw alone is not sufficient to influence the behaviour or physiology of growing pigs, based on the lack of significant differences between treatments in the behavioural testing data and the physiological data. A similar study with three possible stages of enrichment with extra space and access to peat and straw (0-6, 7-12 and 13-18 weeks) showed an increased in ambulation score in an open-field test (Beattie *et al.*, 1995b). The provision of toys, altered weekly, significantly increased the avoidance of a novel object and human

subject by pigs (Pearce and Paterson, 1993). This may demonstrate that extra space with access to substrates or toys may be more suitable outlets for exploratory motivation than limited amounts of straw, although toys were still not enough to counteract the detrimental physiological effects of crowding (Pearce and Paterson, 1993).

Although straw did not appear to be having a significant effect on the behaviour or physiology of the pigs there was a clear increase in skin lesion score at the end of stage 3 (16 weeks) in treatment BEB compared with the other four treatments. A similar finding was reported by Beattie *et al.* (1995b) that pigs reared up to six weeks in enriched conditions and then switched at weaning to a barren environment that had reduced space allowance and no substrates, had a higher incidence of tail-biting. It was suggested that the transition from one environment to another at weaning might have been at a critical stage in the development of pig behaviour. The current findings extend this principle in that transferring from an enriched to a barren environment after eight weeks (four weeks post-weaning) can also influence subsequent behaviour. Although no tail-biting was observed in the current study, the greater number of skin lesions observed in treatment BEB may have been caused by increased social manipulation due to removal of the substrate, as reported by Beattie (1995b). This can directly cause skin lesions or can lead to increased aggression that is also a source of lesions as has been previously reported (Schouten, 1986). Treatment BEB showed significantly higher skin lesions than the other treatments on both replicates and were housed in different pens in each containing no obvious source of lesions in the physical environment. Straw did not affect any of the other measures of welfare as mentioned above, but its removal in stage three of this study did seem to reduce the pigs' welfare as determined by skin lesions. It

is unknown why a similar effect was not observed in the skin lesions measured at the end of stage two following the transition between stage one to stage two in the EBB treatment. It is possible that any lesions caused may have faded in the four week period and any effect on behaviour was short-term or that the straw was more important as a source of enrichment at stage two in the grower accommodation than at stage one in the farrowing crate. Straw bedding has been shown to be preferred by pigs to concrete in a choice test (Beattie *et al.*, 1998)

The significant relationships between high open-field ambulation scores and number of vocalisations, low approach latencies and high levels of interaction in both the novel object and the human approach tests indicates a continuum of arousal/responsiveness in these pigs. This supports an increasing number of reports finding consistent individual behavioural responses to open-field stressors in pigs (Jensen *et al.*, 1995b; Lawrence *et al.*, 1991) and the current findings agree with those of Jensen *et al.* (1995b) that open-field test behaviour is not bimodal in its distribution. The strong correlations between the first contact and number of interactions in novel object test and the first contact and number of interactions in the human approach tests support suggestions made earlier in this project in section 2.5.2, that there are consistent individual behavioural responses to this form of stressor/novelty. The current findings that there was no significant relationship between measures of behaviour and the ACTH challenge results are contrary to those of von Borell and Ladewig (1992) who found a significant, positive relationship between adrenocortical function and locomotor behaviour and vocalisations in an open-field test.



De Jong *et al.* (1998) found that pigs reared in large farrowing pens followed by large pens with straw bedding, which was considered to be an enriched environment, had higher basal serum cortisol levels than those reared in standard farrowing crates followed by smaller, partially-slatted concrete pens, conditions considered to be barren. This difference in basal cortisol levels was the reason for including a measure of immune function, i.e. the KLH response, in this study. Another report from this study published since the current work was carried out has found that that these increased basal serum cortisol levels are not associated with any difference in immune function (De Groot *et al.*, 2000). However, the enriched conditions in these studies included the provision of straw and a considerable increase in space allowance. De Jong *et al.* (1998) attribute the basal cortisol differences to straw, although earlier studies have shown the importance of increased space allowance post-farrowing on the normal development of behaviour (Schouten, 1986), between 25 and 100 kg on reduced cortisol response to an ACTH challenge (Pearce and Paterson, 1993) and between 30 and 60 kg on improved immune response (Turner *et al.*, 1999). Unfortunately, the large variation between replicates in the basal serum cortisol and ACTH challenge data precludes any further comments on whether it was the straw or the space allowance that was responsible for this variation. It appears that although there were no observable differences in procedure or time taken in blood sampling, the pigs in replicate two showed signs of increased stress as indicated by raised serum cortisol concentration. There were still no significant differences due to treatment in replicate one, but the reduction in degrees of freedom may have concealed any real differences.

The lack of any significant treatment differences in the day 21 response to KLH agrees with the findings of De Groot *et al.* (2000), that enriched rearing conditions does not alter the immune response compared with barren rearing conditions if the straw provided in this experiment is considered to be a significant component of the environment.

## 8.6 Conclusions

There was little evidence of providing straw on a daily basis positively affecting the welfare of pigs as indicated by behavioural response to an open-field test, a novel object test, a human approach test, cortisol response or immune function. However, the significant increase in skin lesions noted in treatment BEB may indicate that the straw was having some effect on the pigs' behaviour and that its removal resulted in behaviour that was detrimental to the pigs' well-being.

This study found consistent responses to both the novel object and human approach tests, supporting suggestions made earlier in this thesis (section 2.5.2) and elsewhere (Pearce and Paterson, 1993) that the human subject may be simply regarded by the pig as another source of novelty. The increased responses in these tests were significantly correlated with increased ambulation and vocalisations in an open-field test, suggesting that a common control is influencing this behaviour.

A lack of significant findings, together with extensive variation between replicate in the basal cortisol measures, response to an ACTH challenge and immune response to KLH do not allow any firm conclusions to be drawn from this data.

## CHAPTER 9 ALARM PHEROMONES IN URINE MODIFY THE BEHAVIOUR OF WEANER PIGS.

### 9.1 Introduction

Olfactory stimuli play an important role in social communication in pigs. Pheromones released in urine and saliva have been shown to be important in controlling various aspects of reproduction (Pearce and Hughes, 1987a,b), aggression (McGlone *et al.*, 1987) and suckling behaviour (Morrow-Tesch and McGlone, 1990) in this species.

It has recently been suggested that pheromones may be important in communicating aspects of fear in pigs. Vieuille-Thomas and Signoret (1992) demonstrated the presence of an alarm pheromone in the urine of adult (8-11 months old) gilts ('gilt' – a female pig intended for breeding before her first litter) following restraint in a feeder station. Other gilts subsequently avoided the feeder when it contained urine from gilts restrained for the first time, but did not avoid it when contaminated with urine from gilts accustomed to restraint. It is possible that the urinary pheromones released during this stressful situation by the inexperienced gilts may be the same as those reported by McGlone (1985) as being released by young pigs in response to injections of adrenocorticotrophic hormone (ACTH) and being important in mediating submissive behaviour in fighting pigs (McGlone, 1985).

Alarm pheromones are known to have important roles in other species, for example immunosuppressive effects in mice (*Mus domesticus*)(Cocke and Thiessen, 1990) and inhibition of feeding behaviour in Black-tailed deer (*Odocoileus hemionus*)(Müller-Schwarze, 1971). Unavoidable exposure to "alarm pheromones" in the environment of

pigs may reduce the welfare of these animals by inducing chronic stress responses and immunosuppression. This may be of importance in the increased morbidity seen in recently weaned pigs reared under commercial conditions (Veen et al., 1985) when these animals are kept at high stocking densities at a time considered particularly stressful (e.g. Blecha and Kelley, 1981; Pluske and Williams, 1996). The present study was designed to examine changes in behaviour associated with the production of alarm pheromones in the urine of restrained gilts and to determine the effects of exposure to these pheromones on the behaviour of weaner pigs.

## 9.2 Material and Methods

This study was carried out as two replicates using a total of 12 gilts and 12 weaner pigs. Part 1 of each replicate utilised six gilts and part 2 six weaner pigs.

### Part 1

Twelve gilts (Newsham N-21, seven months of age, 120 kg live weight) from the commercial herd at Harper Adams University College were used to assess the production of the putative alarm pheromones. Six of the gilts were restrained in feeding stalls, having no prior experience of similar treatment (inexperienced gilts) while six were restrained after they had previously experienced the procedure six times over the previous two weeks (experienced gilts). Temporary restraint in a feeder was a normal husbandry procedure used on the unit to allow the gilts to become accustomed to being confined in the individual feeders that they would encounter in the sow house. Prior observations had shown that once the inexperienced gilt tries to exit from the stall but is unable to do so, the procedure appears to become stressful in some individuals, being

accompanied by vocalisations, urination and escape attempts. Such behaviour has been suggested to indicate stress in pigs (Borell and Ladewig, 1992) and be accompanied by an enhanced adrenal response to ACTH (Borell and Ladewig, 1992).

The feeding stalls used for urine collection were fitted with slatted floors covering plastic trays into which the urine drained immediately after urination. The behaviour of each gilt was recorded using scan sampling every minute for 30 minutes. Behaviours recorded were as follows.

#### *9.2.1 Postures*

- Standing** - Supported by legs only.  
**Lying** - Recumbent or sternal lying.

#### *9.2.2 Activities*

- Feeding** - Nose in contact with food/ chewing immediately following contact with food in trough at front of feeder.  
**Defecating** - Self-explanatory.  
**Urinating** - Self-explanatory.  
**Exploratory** - Active nose or mouth contact with pen, floor or fittings.  
**Comfort** - Stretching, shaking, rubbing or scratching.  
**Alert (still)** - Motionless, with eyes open and individual apparently aware of the environment.  
**Inactive** - Eyes shut and individual apparently asleep/ unaware of the environment.  
**Escape** - Attempts at turning around, pushing on back gate or attempts to leave the stall over the front wall.

Urine samples were only used from those gilts that urinated within the 30 minute behaviour recording period (all the gilts under study urinated in the requisite time period). The gilt's urine samples were then ranked according to the percentage of time spent in exhibiting escape behaviour. The urine samples used in the inexperienced and experienced treatments were those collected from gilts exhibiting the most and the fewest escape attempts respectively. These samples were subsequently used in Part 2 of the experiment.

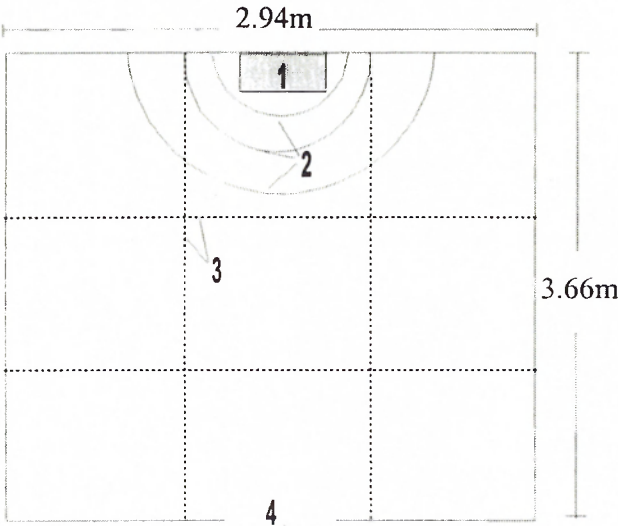
## Part 2

Twelve weaner pigs aged 30-32 days (one week post-weaning) of similar weight ( $9.31 \pm 0.25$  kg) were deprived of food for 6 hours between 0800 h and 1400 h. The pigs were then individually transferred to one of three testing areas at 1400 h. The pigs were exposed to three consecutive tests, one at each testing area. The tests were presented according to a balanced order design in that each possible permutation of the three tests was presented to two pigs (tests 1,2,3; tests 1,3,2; tests 2,1,3, etc.). The tests were:

Test 1) Exposure to a trough sprayed with 50 ml of the inexperienced (high escape behaviour) urine sample.

Test 2) Exposure to a trough sprayed with 50 ml of the experienced (low escape behaviour) urine sample.

Test 3) Exposure to a trough sprayed with 50 ml of water.



**Figure 9.1 Layout of testing pen. (1= feeder; 2= 0.5 m, 1m and 2m graduated distances from feeder; 3= lines dividing test area, 4= entrance to test area)**



Each weaner pig was observed during a two minute open field test immediately following entry to the testing pen with the trough suspended 1.2m above the ground. This was based on the open-field test technique described by Borell and Ladewig (1992) for use with pigs. An ambulation score was determined by counting the number of sections in which the front-right foot of the pig entered. In addition the frequency of all vocalisations (classified as grunts or squeals) and the frequency of urination and defecation were also recorded. After two minutes the trough was lowered onto the ground and the following data recorded over the subsequent 3 minute period:

- i) Latency to approach 1 m from trough.
- ii) Latency to approach 0.5 m from trough.
- iii) Latency to first contact with trough.
- iv) Latency to start of eating.
- v) Time spent at trough (nose protruding over edge of trough).
- vi) Number of eating bouts (separated by at least 5 seconds).
- vii) Number of grunts.
- viii) Number of squeals.
- ix) Number of urinations and defecations.

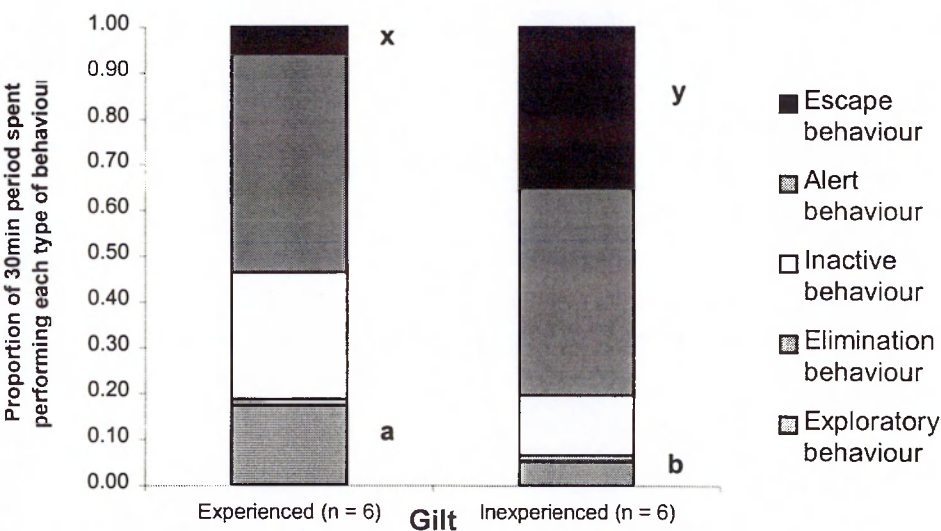
### 9.3 Statistical Analysis

There was no significant effect ( $p>0.05$ ) of order of presentation of the tests, so analysis of the weaner pigs' behaviour in response to the three different treatments was carried out using a randomised block analysis of variance with individual pigs as a blocking factor. Treatment differences between means were identified using protected least significant differences (Snedecor and Cochran, 1980). In order to normalise the data it was transformed according to the equation  $y=\log_e(x+1)$ . Non-parametric data (number of urinations, number of defecations and number of squeals) were analysed using the Kruskal-Wallis technique (Siegel, 1956). All analysis was carried out using Genstat for Windows statistics package (Genstat V, 1995).

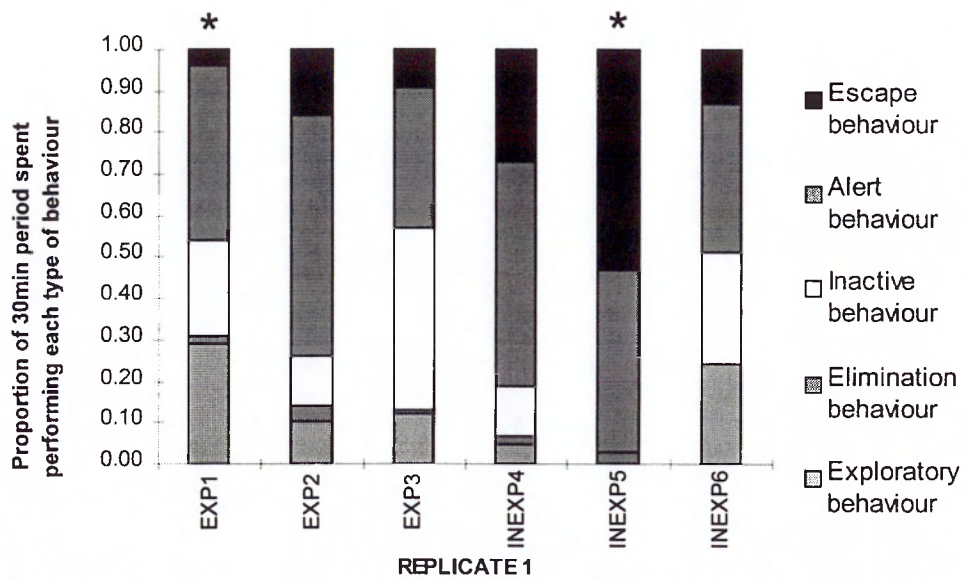
9.4 Results

Part 1

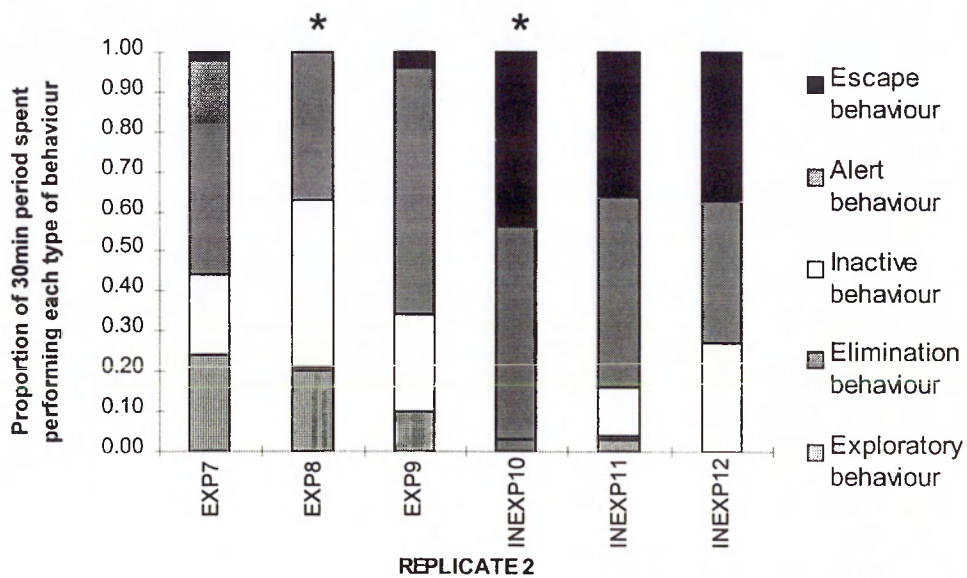
As shown in Figure 9.2, the inexperienced gilts exhibited significantly more escape behaviour ( $p<0.001$ ) and less exploratory behaviour ( $p<0.05$ ) when restrained in the feeders compared to the experienced gilts. The actual behaviours performed by the individual gilts are shown in Figures 9.3a and 9.3b.



**Figure 9.2** The behaviour of gilts during urine collection period whilst restrained in feeding stalls. N.B. superscripts a vs. b and x vs. y indicate significantly different values at  $P<0.05$  and  $P<0.001$ , respectively.



**Figure 9.3a** The behaviour performed by gilts during urine collection period whilst restrained in feeding stalls (replicate 1) (N.B. stars indicate gilts providing samples for experiment).



**Figure 9.3b** The behaviour performed by gilts during urine collection period whilst restrained in feeding stalls (replicate 2) (N.B. stars indicate gilts providing samples for experiment).

Part 2

As shown in Table 1, the mean ambulation score in the open field test was significantly higher when the pigs were exposed to the inexperienced gilts' urine compared to both the experienced gilts' urine and water treatments ( $p<0.01$ ). On presentation with a feeder sprayed with the one of the three types of sample, there were a number of significant treatment effects. The latency of approach to 1 m and 0.5 m was significantly increased in the inexperienced treatment as compared to the water treatment ( $p<0.05$ ). There were no significant differences between the approach latencies of both urine treatments but the experienced treatment also had a significantly increased latency to approach 0.5 m compared with the water treatment ( $p<0.05$ ). Latency to first contact with the feeder was significantly increased in both the treatments involving exposure to urine compared to water ( $p<0.05$ ). The number of eating bouts was higher in the inexperienced treatment compared with the other treatments ( $p<0.05$ ). However, the average duration of these bouts was significantly less in the inexperienced treatment ( $p<0.05$ ) compared with the water treatment with the experienced treatment not being significantly different from either of the other two treatments. Both total vocalisations ( $p<0.01$ ) and the number of grunts ( $p<0.05$ ) were significantly greater in those pigs exposed to the inexperienced gilts' urine compared to the experienced and water treatments.

**Table 9.1** The effect of presence of urine from an inexperienced or experienced gilt and a water control on the behaviour of a weaner pig undergoing an open-field test and subsequent presentation of a feeder.

	Inexpe- rienced	Expe- rienced	Water	SEM
OPEN FIELD TEST				
<i>Ambulation score</i>	18.5 <sup>x</sup>	9.7 <sup>y</sup>	12.3 <sup>y</sup>	1.40
<i>Total vocalisations</i>	51.5	25.3	29.6	5.55
<i>Grunts</i>	41.6	25.3	27.6	4.52
<i>Squeals</i> <sup>KW</sup>	9.9	0.0	2.0	2.45
<i>No. urinations</i> <sup>KW</sup>	0.0	0.1	0.0	0.03
<i>No. defecations</i> <sup>KW</sup>	0.2	0.5	0.1	0.09
FOOD PRESENTATION				
<i>Latency to 1m from feeder (s)</i>	88.4 <sup>a</sup>	72.1 <sup>ab</sup>	43.0 <sup>b</sup>	8.00
<i>Latency to 0.5m from feeder (s)</i>	98.4 <sup>a</sup>	78.6 <sup>a</sup>	48.7 <sup>b</sup>	7.90
<i>Latency to 1st contact with feeder (s)</i>	112.3 <sup>a</sup>	103.8 <sup>a</sup>	57.4 <sup>b</sup>	7.89
<i>Latency to start of eating (s)</i>	126.6	113.5	72.5	9.66
<i>No. of eating bouts</i>	2.8 <sup>a</sup>	1.5 <sup>b</sup>	1.8 <sup>b</sup>	0.27
<i>Average duration of eating bout (s)</i>	16.6 <sup>a</sup>	36.7 <sup>ab</sup>	49.9 <sup>b</sup>	6.00
<i>Total time spent eating (s)</i>	47.8	62.1	97.9	10.42
<i>Total vocalisations</i>	63.0 <sup>x</sup>	41.9 <sup>y</sup>	41.4 <sup>y</sup>	9.44
<i>Grunts</i>	59.3 <sup>a</sup>	41.9 <sup>b</sup>	40.8 <sup>b</sup>	9.10
<i>Squeals</i> <sup>KW</sup>	3.7	0.0	0.6	0.78
<i>No. urinations</i> <sup>KW</sup>	0.0	0.0	0.2	0.04
<i>No. defecations</i> <sup>KW</sup>	0.2	0.3	0.2	0.07

N.B. means with different superscripts in the same row are significantly different; a versus b,  $p < 0.05$ ; x versus y,  $p < 0.01$ .

<sup>KW</sup> indicates analysis carried out using Kruskal-Wallis method – all others carried out using a standard analysis of variance.

## 9.5 Discussion

The results of the present study support the suggestion of Vieuille-Thomas and Signoret (1992) that gilts restrained in a feeder stall release olfactory stimuli in their urine which are perceived as aversive by other pigs. The present study extends these findings by demonstrating that young pigs (weaners) are also able to perceive these pheromones and that they perceive them as aversive.

Examination of the behaviour of the gilts exhibited during their restraint in the feeding stalls indicated that the inexperienced animals with high escape behaviour were clearly alarmed by this restraint whereas the experienced gilts with low escape behaviour generally remained quiet during the observation period (see Figure 9.2). It is therefore considered appropriate in the following discussion to refer to exposure to urine collected from inexperienced gilts as the 'alarm' treatment and urine from the experienced gilts as the 'quiet' treatment.

Ambulation score and vocalisation frequency in open-field tests have been suggested to reflect a pigs' current "level of excitement" (Fraser, 1974; Borell and Ladewig, 1992) and to indicate its "behavioural arousal" (Borell and Hurnik, 1991). In the present experiment the significantly higher ambulation score in the alarm treatment compared with the quiet and water treatments ( $p < 0.01$ ) may indicate a higher state of arousal in these pigs, possibly resulting from an increased motivation to retreat from the aversive stimulus of the alarm pheromones. In addition, on presentation with the feeder there was a significant increase in vocalisations ( $p < 0.01$ ) associated with exposure to the alarm treatment. Increased vocalisations in isolated piglets have recently been reported to be

associated with changes in plasma levels of adrenaline and cortisol (Schrader and Todt, 1998) indicating that the level of vocalisations may be a viable indicator of stress in young pigs. The calls made by piglets separated from the sow have also been suggested to be an indicator of welfare by Weary *et al.* (1997b) with longer and higher pitched calls having been shown to be induced by various stressful situations such as hunger (Weary and Fraser, 1995) and coldness (Weary *et al.*, 1997b) and have been suggested to act as an aid to the sow in locating her offspring. In the present experiment, the increased vocalisations observed in response to the urine of the inexperienced gilt (alarm treatment) may represent the newly weaned piglet's attempts to reunite itself with the sow. Indeed, increased rate of calling of piglets with higher frequency calls of longer duration have been shown to result in stronger responses in sows including orientation towards the source of the vocalisations (Weary *et al.*, 1997a) indicating a survival advantage for this response to aversive stimuli such as alarm pheromones.

In the food presentation test, exposure to urine *per se* (both alarm and quiet treatments) resulted in significantly reduced approach behaviour towards the feeder ( $p < 0.05$ ). However, exposure to the alarm treatment resulted in a significant increase in the number of eating bouts ( $p < 0.05$ ) that were significantly shorter ( $p < 0.05$ ) compared to the other treatments. The increased number of feeding bouts observed in the alarm treatment indicate a strong motivation to feed but the reduced bout duration may indicate inhibition of this motivation by exposure to the urinary pheromone. In addition this observation suggests that the perception of the alarm pheromone may require close proximity to its source as shown to be the case for other pheromones in the pig (Pearce and Paterson, 1992). However, the differences in behaviour between treatments



observed during the open-field test, where the weaner was not in close proximity to the treatment sample, indicates that either a different or additional perception mechanism is operating and/or that there may be more than one pheromone present in the alarmed gilts' urine. McGlone (1985) proposed that urine collected from pigs after injection of ACTH contained a pheromone that induced submissive behaviour when sprayed in the air above regrouped, fighting pigs. After a follow up study (McGlone *et al.*, 1987) it was proposed that there were at least two urinary factors that modulated aggressive behaviour: one, produced in the urine of fighting pigs which decreased aggression, and another produced in the urine of handled pigs which increased aggression. These observations demonstrate that at least two urinary pheromones are produced in response to alarming stimuli in pigs and supports the possibility that at least two urinary factors are responsible for modifying the behaviour of the weaners in the alarm treatment in the present study. Further research in this area will be required in order to clarify the involvement of pheromones in controlling the response of pigs to stressful stimuli.

## 9.6 Conclusions

The production of alarm pheromones in pigs may have important consequences for the welfare of these animals in husbandry systems where pigs are subjected to a number of alarming events such as mixing, regrouping and rehousing particularly when these occur under confined conditions associated with intensive husbandry. Previous work in this species suggests that these pheromones may also be involved in mediating the heightened levels of aggression seen under such conditions (McGlone *et al.*, 1987). Furthermore, evidence from other species (Cocke and Thiessen, 1990) may suggest that exposure to such pheromones can significantly impair immune function and therefore may be involved in the increased morbidity commonly seen in recently weaned pigs (Veen *et al.*, 1985). Therefore further elucidation of the role of these pheromones in pigs would allow a greater understanding of the factors influencing animal welfare in this species.

## CHAPTER 10. THE EFFECTS OF ENVIRONMENT ON THE HEALTH AND WELFARE OF GROWING PIGS – GENERAL DISCUSSION

### 10.1 Introduction

The aim of this thesis was to identify factors within the social and physical environment that influenced the welfare of growing pigs kept under commercial conditions. Broom (1986) stated that the welfare of an animal was its ability to cope with its environment. This definition of welfare from among many others (e.g. Dawkins, 1980; Duncan and Petherick, 1989; Barnett and Hemsworth, 1990; Barnard and Hurst, 1996) has been used during this project and has therefore required measurement of both physiological and behavioural indicators of wellbeing. There are now endless studies that describe the effects of different aspects of the environment on the welfare of growing pigs kept under experimental conditions. These include the benefits of good handling on a pig's fear of humans (Hemsworth *et al.*, 1996), increased space allowance on immune function (Turner *et al.*, 1999), solid pen divisions on respiratory disease (Stark *et al.*, 1998) and the reduction in the welfare of animals subjected to regrouping (Hessing and Tielen, 1994). However, there is very little information describing how these findings relate to what is actually occurring in commercial practice and their relative importance. This study has looked at a wide range of welfare indicators on the farm, in lairage and post-slaughter in order to provide such information. This data has then been subjected to multivariate analysis in order to identify influential factors relating to the rearing environment and management practice that mediate variation in these measures of welfare and also provides some insight into their level of importance. This method of statistical analysis does provide accurate determinations of associations between farm factors and measures of welfare, but does not conclusively state what is the exact nature between these variables. The single factor consistently identified as being associated

with indicators of good welfare was the provision of straw bedding. This was investigated in further detail to see what influence straw may have on behaviour, immune function and stress physiology.

## **10.2 Factors within the rearing environment that affect pig welfare**

### *10.2.1 Assessment of pig welfare in commercial conditions*

Rushen and Passillé (1992) stated that criteria for assessing animal welfare can be divided into design criteria and performance criteria. Design criteria are those factors that are important to ensure an animal's wellbeing and includes space allowance, group sizes, feeding practice, access to manipulative substrates, etc. Extensive study has been carried out in this area and has resulted in the creation of systems for the assessment of welfare, such as the Austrian "Animal Needs Index" ANI 35L or the German equivalent TGI 200 (Bartussek, 1999). Although there are a number of reports of the effects of environment on performance criteria for pigs, for example environmental enrichment on behaviour and production (Beattie *et al.*, 1995a), environmental factors on pneumonia severity (Done, 1991), feeding regime on welfare indicators (Stewart *et al.*, 1994), there is little information in this area concerning commercial practice, particularly in the UK. Broom (1996) advocates the use of a range of indicators to assess the welfare of pigs, including abnormalities in behaviour, disease incidence and injury. He states that wherever pigs are diseased or injured their welfare is not as good as that of healthy pigs. Although there can be major differences in welfare between those pigs severely affected and those slightly infected and some injuries being more detrimental than others, evaluation of these effects is important in comparing the welfare of pigs in different housing and management systems (Broom, 1996).

### 10.2.2 *The effect of floor type on pig welfare*

The floor type of the rearing accommodation of either the lying or dunging areas of the pen has been shown to be an important predictor of the welfare of pigs in this project. The use of slatted floors has been associated an increase in skin lesions, respiratory disease and tail-biting (chapter three), bursitis (chapter five), stomach ulcers (chapter six) and signs of pleuropneumonia (chapter seven). These results clearly show that there are inherent welfare problems with this floor type. Slatted systems are designed to improve hygiene and reduce labour in pig housing by more efficient separation of the pig from its faeces, a potential source of pathogens. It also allows for more effective cleaning between batches of pigs than a solid floor or deep straw bedding. Substrates such as straw or sawdust are not generally used with this system due to problems in slurry management. However, inadequate cleaning of slatted floors may be associated with enteric disease (McOrist, 1997) and partially slatted floors have been associated with an increase in scour problems (Pearce, 1999). Other characteristics of this floor type that may be negatively influencing the welfare of the pigs are draughts (Scheepens *et al.*, 1991a; 1991b), a reduced surface area for support (Mouttotou *et al.*, 1998a) and a lack of complexity of the environment (Pearce *et al.* 1989). This combination of potential stressors may be additive in their effects (Hyun *et al.*, 1998) and the results of the current study suggest that this floor type is not a suitable factor for maintaining the well-being of growing pigs.

The presence of straw bedding has been found to reduce the fear of humans by finisher pigs (chapter two), increase lorry unloading times at arrival at a slaughter plant (chapter four), reduce the prevalence of bursitis (chapter five), reduce the prevalence of gastric ulcers (chapter six) and when provided at the grower stage was associated with an

increased level of serum Major Acute Phase protein (an indicator of inflammatory disease) at slaughter (chapter seven). Although increased unloading times and acute phase response are not indicators of improved wellbeing, the overall effect of straw bedding seems to be an important one for increasing pig welfare. It was suggested in chapters two, three and four that straw might be providing a source of environmental enrichment, which was influencing the level of the response to humans, tail-biting and lorry unloading times. However, in chapter eight providing 0.5 kg of fresh unchopped straw every day did not result in any significant difference in response to novelty, a human subject or an open field test. Evidence from chapter eight suggests that provision of unchopped straw has limited effect on pig welfare, in that it doesn't affect behavioural coping mechanisms, immune function or adrenocortical function. Therefore, it is likely that the factor called straw bedding, which was important in mediating those welfare indicators in the farm and lairage studies may actually represent a number of characteristics apart from simply the provision of straw. In addition to providing a manipulative substrate as a source of enrichment (Arey, 1993), straw may provide floor insulation (Bruce and Clark, 1979), provide a source of gut fill (Lawrence *et al.*, 1988) and may be associated with increased space allowance, which has also been found to influence welfare indicators in this study and is an important factor in behavioural development (Schouten, 1986).

### *10.2.3 The effect of space allowance, pen size and group size and on pig welfare*

Previous studies have demonstrated that space allowance has important effects on growth (Turner *et al.*, 2000), skin lesions (Turner *et al.*, 2000), immune function (Turner *et al.*, 2000), adrenocortical function (Pearce and Paterson, 1993) and the

development of agonistic behaviour (Schouten, 1986). In the current study increased space allowance at the grower stage was associated with an increase in the difficulty of handling at unloading and an increase in finisher space allowance was associated with a reduction of agonistic interactions in the lairage pen following transport (chapter four). An increase in the difficulty of handling may not be indicative of improved welfare. Indeed welfare may be reduced if lairage staff have to be more forceful in moving a pig to the lairage pen. However, a reduction in the level of fighting suggests that the welfare of pigs in lairage can be improved through increased space allowance during the latter stages of rearing. This is supported by other work stating that the level of fighting in pigs mixed in lairage could be predicted by the level of aggressive behaviour shown in the home pen (Geverink *et al.*, 1998a) and that agonistic behaviour in the pen is controlled by space allowance (Baxter, 1985). A number of studies have incorporated increased space allowance and provision of a substrate into enriched environment treatments and have found improved growth, reduced manipulative behaviour directed towards pen mates and reduced associated aggression (Beattie *et al.*, 1993; 1995; Jonge *et al.*, 1996; O'Connell *et al.*, 1999; Olsson *et al.*, 1999; De Jong *et al.*, 2000). However, evidence from the current study (chapter eight) that providing straw without an increase in space allowance has minimal effect on the behavioural and physiological parameters measured in this study, which suggests that space allowance may be more important to the well-being of pigs.

In addition to space allowance, finisher pen size was also found to be associated with reduced human approach latencies (chapter two) and a reduction in serum haptoglobin concentration at slaughter (chapter seven). The reduced human approach latency indicates a decreased fear of humans (Hemsworth *et al.*, 1993) and is therefore

indicative of improved animal welfare. The reduction in fear to approach a human in those pigs in larger pens may be due to the greater ease of movement without disturbing another individual and is supported by other work reporting an increase in exploratory behaviour in pigs kept in larger pens (Pearce and Paterson, 1993). The reduction in serum haptoglobin indicates a decrease in inflammatory disease (Heergaard *et al.*, 1998). There are no other detailed studies of the effects of the commercial environment on the acute phase response of growing pigs, but an increase in overall pen area has been shown to have a protective effect on systemic infection (Tuovinen *et al.*, 1990). An increase in pen size may result in less social contact between pigs (McGlone and Newby, 1994), which is the most common route for the transmission of respiratory diseases (Stark, 2000) that cause an acute phase response (Heergaard *et al.*, 1998). It is possible that the larger pens would mean that there was less overlying of pigs and therefore reduced damage to the skin from hooves that could lead to infection and an associated acute phase response.

An increase in grower group size was found to be associated with reduced bursitis at slaughter (chapter 5). Larger group sizes have been found to show more restlessness (Ewbank and Bryant, 1969; Ross and Curtis, 1976; Randolph *et al.*, 1981) and be associated with reduced growth suggested to be due to the increased energy cost involved in greater locomotory activity (Turner *et al.*, 2000). Bursae formation can be reduced with a reduction in resting behaviour (Moultotou *et al.*, 1998a) supporting the current findings that suggest increased group size results in greater activity and therefore a reduction in resting behaviour and associated bursitis.



#### 10.2.4 Ventilation and air quality

Increased ammonia was associated with increased tail-biting and increased prevalence of signs of diarrhoea in finisher pigs (chapter three). Increased humidity was associated with increased skin lesions (chapter three) and fan-assisted ventilation in grower accommodation was associated with increased signs of enzootic pneumonia, whilst when present in finisher accommodation was associated with increased Major Acute Phase protein concentration at slaughter, but a reduction in signs of pleuropneumonia (chapter seven). These findings suggest the importance of the aerial environment in influencing pig health and welfare. Increased ammonia is aversive to pigs (Jones *et al.*, 1996) and is indicative of poor ventilation, as are high humidity levels. Ammonia also causes paralysis and denudes the cilia lining of the respiratory tract and so reduces the rate of clearance of pathogens (Christensen and Mousing, 1992). Increased humidity has a direct effect on increasing perceived temperature of the pig due to reduced evaporative cooling, which may be detrimental to immune function, also affecting the prevalence of respiratory disease (Machado-Neto *et al.*, 1987). Increased humidity may lead to increased pathogen survival as they can survive in water droplets, but are vulnerable to desiccation (Christensen and Mousing, 1992).

Fan-assisted ventilation may be associated with reduced ventilation rates, which can lead to increased prevalence of respiratory disease (Stark, 2000) and was associated with an increase in signs of enzootic pneumonia in grower pigs in the current study. However, it was also associated with reduced signs of pleuropneumonia in finisher pigs, which may relate to differences in the routes of infection of the different pathogens.

### 10.2.5 Feeding and watering methods

Various factors associated with the provision of food and water have been identified as being important in their association with pig welfare. Increased trough length was associated with increased tail biting and increased signs of diarrhoea (chapter three). These associations are difficult to explain in causative terms, but it is possible that increased trough length represents a combination of factors such as group size, housing system and food type, although no strong correlations existed between these factors. Food type has been found to affect other measures of welfare in the current study. Pelleted finisher diets were associated with increased prevalence of gastric ulceration (chapter six), supporting the results of previous work (Potkins *et al.*, 1989; Wondra *et al.*, 1995). The use of wet feeding systems has been linked with an increase in enteric disease (Pearce, 1999), possibly due to reduced hygiene standards associated with wet feeding (Brooks *et al.*, 1996). This increase in infection pressure may also be responsible for the increase in signs of pleuropneumonia seen in chapter seven, supporting previous reports of a relationship between diarrhoea and respiratory disease (Tuovinen *et al.*, 1997). It is most common for wet-fed pigs to eat simultaneously, which would increase contact between pigs and therefore increase the chance of transmitting pathogens by nose to nose contact, this being the most common route of transmission for *Actinobacillus pleuropneumoniae* (Stark, 2000).

An increased number of pigs per drinker was associated with a reduction in grower lesion score (chapter three), whilst *ad libitum* provision of water for finishers was associated with reduced serum C-reactive protein concentration at slaughter (chapter seven). Contrary to the current findings, a previous study found no effect of drinker

allocation on skin lesion score (Turner *et al.*, 1999). The increased number of drinkers found on farms in the current study may represent efforts to reduce aggression problems or may represent factors not categorised in this work. A reduced number of drinkers was found to decrease the human approach behaviour of growers (chapter 2). This evidence and the finding that dirtier pigs also showed decreased approach behaviour suggests that reduced drinkers were indicative of poor general environmental conditions, which may have reduced the ability of the pigs to cope with a human stressor. Lack of *ad libitum* access to water has been identified as a risk factor for respiratory disease (Tuovinen *et al.*, 1997) due to dehydration of the protective mechanisms of the respiratory tract, i.e. a reduction in the protective mucous membrane and therefore the associated increase in serum C-reactive protein concentration at slaughter may represent an increase in inflammatory disease.

#### 10.2.6 Stockmanship

Stockmanship is a very important factor in mediating pig welfare (Rushen and Passillé, 1992; Hemsworth *et al.*, 1993). The term stockmanship may represent actual human-animal interaction or husbandry methods employed in the care of pigs. There is evidence from this study of both types of stockmanship having effects on pig welfare. Increased human approach behaviour indicating a reduced fear of humans was shown to be associated with a concrete dunging area requiring a tractor drag through system of cleaning. This husbandry technique would result in increased human contact as the stockman drives the pigs into the lying part of the pen and this increased contact time appeared to reduce the pigs' fear of humans. The importance of the quality of human contact in terms of active pleasant and unpleasant handling regimes on pig health and welfare is well-documented (Hemsworth *et al.*, 1993). This is supported by the evidence

from chapter 9 that exposure to handling perceived as aversive can result in the production of alarm pheromones that could also affect pig welfare. Therefore, the findings presented in chapter 2 may indicate that non-aversive contact is beneficial to pig welfare, in terms of reduced fear of humans.

Other general husbandry factors such as herd size, treatment of individual pigs using injections, tail docking and the use of batch system on an all-in all-out basis were identified as being associated with various indicators of welfare. Increased herd size was associated with increased clinical signs of respiratory disease and tail-biting in grower pigs and may reflect an increase in virulence and an increased infection pressure, supporting suggestions made by Hartung (1994) accompanied by a reduction in inspection of individual animals, as suggested by Blackshaw (1981). Other evidence for the benefits of increased inspection may be demonstrated by the individual treatment of grower pigs by injection being associated with reduced serum amyloid A concentration at slaughter, showing reduced disease. Individual treatment of pigs may represent an increase in individual inspection, which appears to have benefits for pig health and welfare. However, individual injection of finishers was associated with increased signs of enzootic pneumonia and higher serum Major Acute Phase protein concentrations at slaughter, although treatment at this stage may represent attempts to minimise outbreaks of respiratory disease by immediate medication of diseased individuals and penmates (Christensen and Mousing, 1992).

Both tail- docking and all-in all-out management procedures were associated with increased bursitis (chapter five). Neither of these factors are likely to be causative in their relationship but, as discussed in section 5.5, tail docking may indicate increased

problems with tail-biting due to a poor environment. The characteristics of the environment associated with all-in all-out management and their possible effects on bursitis and other measures of welfare have yet to be investigated.

### 10.3 Important rearing periods that affect pig behaviour

A number of the behavioural indicators of welfare at the finisher stage and in lairage before slaughter were more strongly associated with factors within the rearing environment at the grower stage than those in their current environment. These included associations between increased human approach behaviour of finishers (chapter 2) and reduced skin lesions in lairage (chapter 4) of pigs previously reared with straw bedding at the grower stage, increased prevalence of tail-biting in finishers previously reared on slatted floors (chapter 3) and increased ease of handling in lairage of pigs reared in larger space allowances at the grower stage (chapter 4). This suggests that the rearing period following weaning may be a critical period for the behavioural development of pigs, which affects subsequent performance of behaviours that affect pig health and welfare. There is evidence of a sensitive period that exists in the three weeks after birth (Hemsworth and Barnett, 1992) that influences subsequent behavioural response towards humans. Other studies have demonstrated the importance of the pre-weaning environment on the development of social behaviour (Schouten, 1986; Beattie *et al.*, 1995a). However, there are no previous reports stating the importance of rearing environment of the pig later in life in affecting behaviour apart from the numerous reports about the effects of current environment (e.g. Moore *et al.*, 1994; Beattie *et al.*, 1996; De Jong *et al.*, 1998). Evidence from other species suggests that post-weaning rearing conditions can be important in behavioural development, such as found in rodents (Korn and Moyer, 1968; Valzelli, 1973; Riittinen *et al.*, 1986), dogs and cats (Bateson, 1979) and that sensitive periods can exist in farmed animals during certain events such as at first calving (Hemsworth *et al.*, 1987). The presence of a sensitive period during the early grower stage for pigs may also explain previous apparently

contrary results concerning the effects of an enriched environment on subsequent response to humans (Pearce *et al.*, 1989; Pearce and Paterson, 1993), discussed in section 2.5.2.

In addition to sensitive periods of behavioural development evidence from the current study (chapter 8) suggests that a change in environmental complexity can also influence subsequent pig behaviour, specifically behaviour that results in an increase in skin lesions due to a change from an environment enriched with straw to one without straw. An increase in exploratory behaviour directed at penmates and associated aggression in pigs initially reared in enriched conditions and transferred at weaning to a barren environment has previously been reported (Beattie *et al.*, 1995a). It has been suggested that animals reared in an enriched environment are subject to greater arousal during rearing and are less likely to become excitable in a novel or highly stimulating environment (Walsh and Cummins, 1975; Grandin, 1989). It is well known that pigs reared in conditions with reduced environmental complexity can demonstrate behaviour described as excitable or over-responsive to stimuli (Grandin, 1989; Pearce and Paterson, 1993). Therefore it may be possible that the change from an enriched to a barren environment may exacerbate the response to the barren conditions due to the lack of development of a suitable coping strategy, such as the reduction in activity seen in pigs housed in barren conditions (Wood-Gush and Beilharz, 1983).

#### 10.4 Behavioural testing

In the current study, specific behavioural tests have been utilised to elicit responses that may indicate differences in a pig's wellbeing. In chapter two, an adaptation of the human approach test reported by Hemsworth *et al.* (1981) for use with groups of pigs kept in commercial conditions was successfully used to differentiate between the effects of various environmental conditions on pig welfare. This was a relatively simple procedure that did not require a long time and may be regarded as a useful indicator of the welfare of pigs kept in a variety of commercial conditions. However, evidence from chapter two suggests that there may be two conflicting motivations controlling the human approach behaviour of pigs, the motivation to retreat from the human subject due to aversion and the motivation to explore the human subject as a source of novelty. It is generally accepted that human approach behaviour is a direct measure of a pig's fear of humans as a result of previous human-animal interaction (Hemsworth *et al.*, 1993). The current study demonstrates that other factors influence this measure of welfare and that these should be considered when comparing pigs' fear of humans in different environments using this test, particularly levels of complexity and pen area provided during rearing.

The use of an open-field test was successful in detecting a difference in behaviour of piglets exposed to alarm pheromones and those exposed to control urine samples and water. The findings of chapter nine supported previous suggestions of increased ambulation score in an open-field test indicating increased arousal (Borell and Hurnik, 1991). When presented with a feeder sprayed with the alarm pheromone the piglets performed more vocalisations than those presented with a feeder sprayed with neutral



urine or water. This form of behaviour has been demonstrated to result in stronger responses in sows including orientation towards the source of the vocalisations (Weary *et al.*, 1997a) and supports suggestions of the importance of vocalisations as indicators of welfare (Weary & Fraser, 1995; Weary *et al.*, 1997b; Schrader & Todt, 1998).

### 10.5 Overall conclusions

This project has identified factors within the rearing environment of growing pigs that have an important influence on their health and welfare. Floor type, particularly the provision of straw bedding; increased space allowance per pen and group size; improved ventilation and air quality; methods of food and water provision and aspects of stockmanship have all been shown to affect the welfare status of the pigs. In addition, evidence from the current study suggests that the rearing period immediately post-weaning has an important influence on behavioural development and response of the finisher pig to stressors, such as human presence in the home pen, handling and regrouping in lairage prior to slaughter. The results also indicate that a change from an enriched environment to a less complex one may have effects on behaviour that may be detrimental to welfare. Further work is required to understand the underlying behavioural mechanisms that may be affected at this critical stage in the pig's development, particularly those influenced by environmental complexity.

Novel tests utilised in this project including a version of the standard human approach test for use with group housed pigs and the assessment of immune function and serum acute phase protein concentrations as indicators of health, are useful in the assessment of pig welfare in commercial conditions. However, a knowledge of the detailed underlying physiological mechanisms of these responses must be sought and care must be taken when interpreting data from such trials.

Gilts subjected to an alarming experience can produce pheromones aversive to other pigs that may have important consequences for the welfare of these animals in husbandry systems where pigs are subjected to a number of alarming events such as

mixing, regrouping and rehousing particularly when these occur under confined conditions associated with intensive husbandry.

In order to improve the assessment of the welfare of pigs in commercial practice, it is necessary to devise a series of practical indicators that may be used to compare existing and new husbandry systems. Candidates for this include the use of the human approach test and handling observations in order to evaluate the mental state of the pig and the use of acute phase proteins in live animals and at slaughter as a measure of general health status. Future investigations should examine further how the physical environment may influence a pig's behavioural response to stressors and ascertain how measurements of the acute phase response may be implemented in disease prevention and treatment programmes.

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**APPENDIX 1 – Farm details checklist (for chapters 2-6)**

**On-Farm Investigation Checklist**

**Date:**

**Farm Details:**

**Weather:**

**Outside temperature/humidity:**

**General description of unit:**

**Slaughterhouse:**

**How many stages:**

**How are they moved:**

**How often are they weighed:**



Date: \_\_\_\_\_

## Farrowing accommodation & weaner details

**Farrowing accommodation:**      Farrowing crate ☐  
                                                  Other ☐ \_\_\_\_\_

**Teeth clipped:**      yes ☐    no ☐      **Tail-docked:** yes ☐    no ☐

### *Weaner housing*

**Weaner accommodation type:**      solid floor ☐  
                                                  slatted floor ☐  
                                                  partial slats ☐  
                                                  mesh floor ☐  
                                                  partial mesh floor ☐  
                                                  shavings ☐  
                                                  straw ☐  
                                                  other: \_\_\_\_\_

**Group size:** \_\_\_\_\_

**Pen size:** \_\_\_\_\_

### *Environmental factors*

**Temperature:** \_\_\_\_\_

**Humidity:** \_\_\_\_\_

**Ammonia concentration (ppm):** \_\_\_\_\_

**Hydrogen sulphide concentration (ppm):** \_\_\_\_\_

**Grower Human Approach Tests**

**Date:**

Farm:

Test no.	1	2	3	4	5	6	7	8
No.of pigs in pen								
Latency to 1 pig approaching 0.5m								
Latency to 1 pig interacting								
Latency to _____ (25%) approaching								

Farm:

Growers' details

Description:

Pen width: \_\_\_\_\_ Lying area length: \_\_\_\_\_ Dinging area length: \_\_\_\_\_ Group size: \_\_\_\_\_

Trough length : \_\_\_\_\_ No, of feeder spaces : \_\_\_\_\_

No.drinkers : \_\_\_\_\_ Flow rate : \_\_\_\_\_

Human contact:

Feeding method: Automatic ☐ Semi-auto. ☐ Manual ☐  
Building type: Open ☐ Closed ☐ Semi-closed ☐  
Dung disposal Slats & drains ☐ Tractor ☐ Manual ☐  
Exposed to farm activity yes ☐ no ☐

Coughs and sneezes:

No. of pigs				
Coughs				
Sneezes				

Temperature: °C	Lying								
	Dunging								
Humidity	Lying								
	Dunging								
Ammonia concn. ppm	Lying								
	Dunging								
H <sub>2</sub> S concn. ppm	Lying								
	Dunging								

Draughts:  
(m/s)

	1	2	3	4	5	6	7	8
Lying area								
Dunging area								

Lesion score sheet

Date:

Farm:

Pig category:

Pig no.	Face	L. ear	R. ear	Neck	Back	L. flank	R. flank	L 1/4	R 1/4	Total	Foot dam/burs.	Tail scr
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

Cleanliness score sheet

Date:

Farm:

Pig category:

Pig no.	Pen cleanli ness	F. legs	B. legs	L. flank	R. flank	Hind- quarter s	Head	Total	Diarrh oea
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

**Finisher Human Approach Tests**

**Date:**

Farm:

Test no.	1	2	3	4	5	6	7	8
No.of pigs in pen								
Latency to 1 pig approaching 0.5m								
Latency to 1 pig interacting								
Latency to _____ (25%) approaching								

Farm:

Finishers' details

Description:

Pen width:\_\_\_\_\_ Lying area length:\_\_\_\_\_ Dinging area length:\_\_\_\_\_ Group size:\_\_\_\_\_

Trough length :\_\_\_\_\_ No, of feeder spaces :\_\_\_\_\_

No.drinkers :\_\_\_\_\_ Flow rate :\_\_\_\_\_

Human contact:

Feeding method: Automatic ☐ Semi-auto. ☐ Manual ☐  
Building type: Open ☐ Closed ☐ Semi-closed ☐  
Dung disposal Slats & drains ☐ Tractor ☐ Manual ☐  
Exposed to farm activity yes ☐ no ☐

Coughs and sneezes:

No. of pigs				
Coughs				
Sneezes				

Temperature: °C	Lying								
	Dunging								
Humidity	Lying								
	Dunging								
Ammonia concn. ppm	Lying								
	Dunging								
H <sub>2</sub> S concn. ppm	Lying								
	Dunging								

Draughts:  
(m/s)

	1	2	3	4	5	6	7	8
Lying area								
Dunging area								

Lesion score sheet

Date:

Farm:

Pig category:

Pig no.	Face	L. ear	R. ear	Neck	Back	L. flank	R. flank	L 1/4	R 1/4	Total	Foot dam/burs.	Tail scr
1												
2												
3												
4												
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Cleanliness score sheet

Date:

Farm:

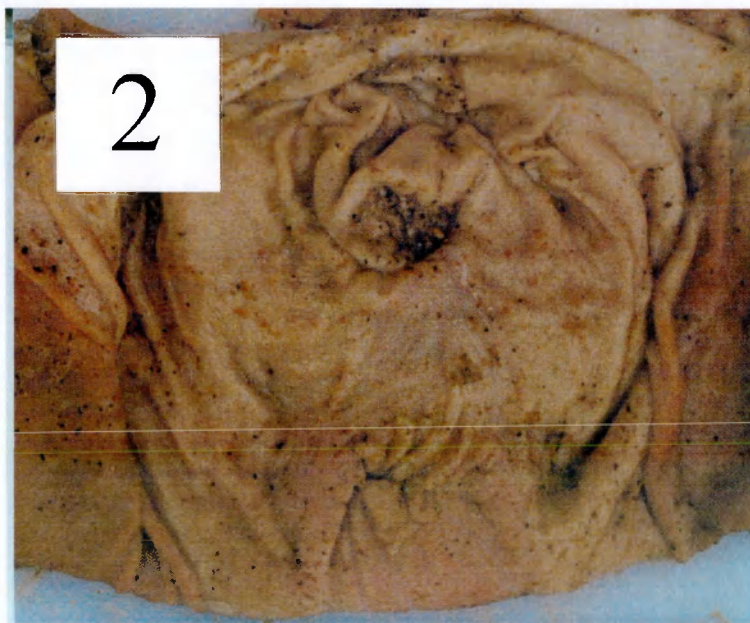
Pig category:

Pig no.	Pen cleanli ness	F. legs	B. legs	L. flank	R. flank	Hind- quarter s	Head	Total	Diarrh oea
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
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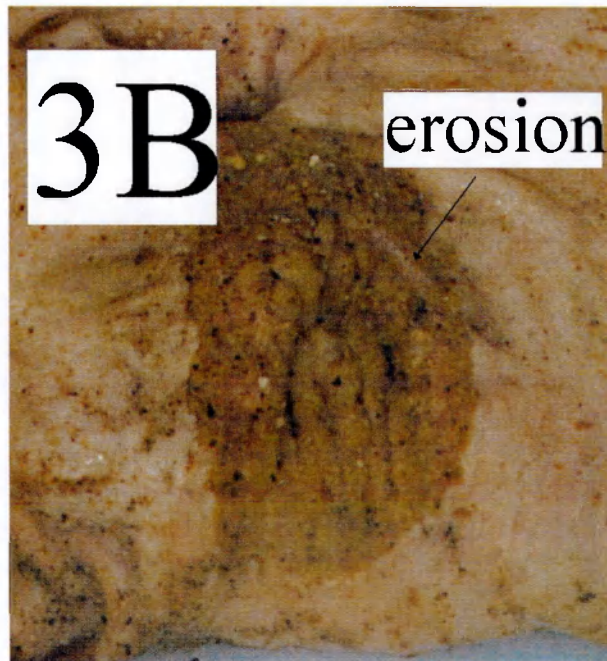
**APPENDIX 2 – Scoring system for Gastric Ulceration (Chapter 6)**



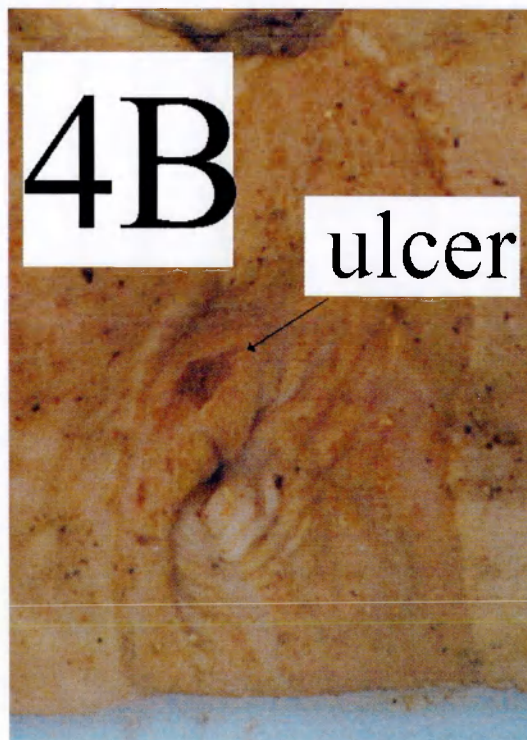
**A smooth, bile staining-free pars oesophageal region of a pig's stomach equating to a stomach ulcer score of 0.**



**A pars oesophageal region of a pig's stomach showing hyperkeratosis (less than 1mm thickening) equating to a stomach ulcer score of 2.**



**A pars oesophageal region of a pig's stomach showing hyperkeratosis (greater than 1mm thickening) and bile staining equating to a stomach ulcer score of 3B.**



**A pars oesophageal region of a pig's stomach showing hyperkeratosis (greater than 1mm thickening), bile staining and a small erosion equating to a stomach ulcer score of 4B.**





**A pars oesophageal region of a pig's stomach showing hyperkeratosis (greater than 1mm thickening), bile staining and two large erosions (about 2.5-3 cm) equating to a stomach ulcer score of 5B.**



**A pars oesophageal region of a pig's stomach showing hyperkeratosis (greater than 1mm thickening), bile staining and two large erosions (about 5-6 cm) equating to a stomach ulcer score of 6B.**

APPENDIX 3 – Farm details questionnaire for Pneumonia and Acute Phase protein study (Chapter 7).

ENVIRONMENTAL RISK FACTORS AND PNEUMONIA IN PIGS QUESTIONNAIRE

1. Identification

Name: \_\_\_\_\_

Farm name: \_\_\_\_\_

Address: \_\_\_\_\_

Ph. / Fax: \_\_\_\_\_

Best time to ring: \_\_\_\_\_

How often are pigs transported to the abattoir? (please tick): weekly ☐; fortnightly ☐

Average number of pigs shipped .

Usual day of slaughter (please tick) :

Monday ☐; Tuesday ☐ Wednesday ☐; Thursday ☐; Friday ☐ ; variable ☐.

Approximate time of arrival at abattoir?  Live weight at slaughter

1.1    Number of sows:     Number of grower/finishers:

         Weaning age:

Number of production stages after weaning:        1   2   3   4   5   6   (circle)

STAGE	1	2	3	4	5
Age (weeks)					
Weight (kg)					
Mixed? (tick)					
Group size					

2. Location

2.1. Distance to nearest pig farm (miles):

2.2. Distance to nearest pig farm in direction of prevailing wind:

2.3. Number of farms within a 2 mile radius:

### 3. Current herd health status

#### 3.1. Are you using any of the following preventive measures? (please tick)

Vaccination against	<input type="checkbox"/> yes	Vaccination against	<input type="checkbox"/> yes
<i>Mycoplasma hyopneumoniae</i> (enzootic pneumonia)	<input type="checkbox"/> no	<i>Actinobacillus pleuropneumoniae</i> (pleuropneumonia)	<input type="checkbox"/> no

#### 3.2. Have you observed any of the following conditions during the last two weeks? (please tick)

Coughing in piglets up to 20 kg (weaners)	<input type="checkbox"/> yes <input type="checkbox"/> no	Coughing in pigs 45-100 kg (finishers)	<input type="checkbox"/> yes <input type="checkbox"/> no
Coughing in pigs 20-45 kg (growers)	<input type="checkbox"/> yes <input type="checkbox"/> no	Diarrhoea in any age group	<input type="checkbox"/> yes <input type="checkbox"/> no

#### 3.3. Have you been using antibiotic medicated feed or other antibiotic treatments during the last two weeks for any health disorder or as a prevention? (please tick)

in-feed medication of pigs in the grower stage	<input type="checkbox"/> yes <input type="checkbox"/> no	individual treatments of grower pigs by injection	<input type="checkbox"/> yes <input type="checkbox"/> no
in-feed medication of pigs in the finisher stage	<input type="checkbox"/> yes <input type="checkbox"/> no	individual treatments of finishers by injection	<input type="checkbox"/> yes <input type="checkbox"/> no

---

### 4. Management

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#### 4.1 Please estimate the cleanliness of your pigs (please circle one)

n.b. 0 = very clean (0% skin covered by dung), 10 = very dirty (100% skin covered by dung)

Growers            0   1   2   3   4   5   6   7   8   9   10

Finishers           0   1   2   3   4   5   6   7   8   9   10

#### 4.2 I consider the hygiene status of my farm to be (please tick one)

Good	<input type="checkbox"/>
Adequate	<input type="checkbox"/>
Could be better	<input type="checkbox"/>

#### 4.3 I consider environmental factors (temperature, humidity, air quality etc.) to be important for swine health (please tick one)

Yes, very important	<input type="checkbox"/>	No, not very important	<input type="checkbox"/>
Yes, some importance	<input type="checkbox"/>	No, doesn't make any difference	<input type="checkbox"/>

#### 4.4 I consider the current environment for the pigs on my farm to be: (please tick one)

Good	<input type="checkbox"/>	Could be better	<input type="checkbox"/>
Adequate	<input type="checkbox"/>		

## 5. Housing

### 5.1. Grower pigs (*please tick*)

Ventilation is supported by fans	<input type="checkbox"/> yes <input type="checkbox"/> no
The ventilation is automatically controlled (thermostat)	<input type="checkbox"/> yes <input type="checkbox"/> no
The threshold temperature in the grower pen is set to	°C
Pigs are mostly fed wet feed, e.g. wet-dry feeding	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs have unlimited access to drinking water (ad lib)	<input type="checkbox"/> yes <input type="checkbox"/> no
There is a liquid manure system and slatted floors	<input type="checkbox"/> yes <input type="checkbox"/> no
Effluent is removed	<input type="checkbox"/> daily <input type="checkbox"/> less <input type="checkbox"/> more
Bedding (such as straw, wood shavings) is being used	<input type="checkbox"/> yes <input type="checkbox"/> no
All pen separations are solid (no possibility for nose to nose contact)	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs less than 12 weeks old are sharing room with pigs 5 or more weeks older than them	<input type="checkbox"/> yes <input type="checkbox"/> no
Average size of pen (m <sup>2</sup> )	_____
Average number of pigs per pen	_____
Maximal number of pigs per pen	_____
Average number of pigs per closed room	_____
Maximal number of pigs per closed room	_____
Approximate volume of room (m <sup>3</sup> )	_____
Pigs are moved through the grower sections following an all-in/all-out system, i.e. sections will be completely emptied, cleaned and disinfected between batches	<input type="checkbox"/> yes <input type="checkbox"/> no

### 5.2. Finisher pigs

Ventilation is supported by fans	<input type="checkbox"/> yes <input type="checkbox"/> no
The ventilation is automatically controlled (thermostat)	<input type="checkbox"/> yes <input type="checkbox"/> no
The threshold temperature in the finisher pen is set to	°C
Pigs are mostly fed wet feed, e.g. wet-dry feeding	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs have unlimited access to drinking water (ad lib)	<input type="checkbox"/> yes <input type="checkbox"/> no
There is a liquid manure system and slatted floors	<input type="checkbox"/> yes <input type="checkbox"/> no
Effluent is removed	<input type="checkbox"/> daily <input type="checkbox"/> less <input type="checkbox"/> more
Bedding (straw, wood shavings) is being used	<input type="checkbox"/> yes <input type="checkbox"/> no
All pen separations are solid (no possibility for nose to nose contact)	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs more than 12 weeks are sharing room with pigs 5 or more weeks younger than them	<input type="checkbox"/> yes <input type="checkbox"/> no
Average size of pen (m <sup>2</sup> )	_____
Average number of pigs per pen	_____
Maximal number of pigs per pen	_____
Average number of pigs per closed finisher room	_____
Maximal number of pigs per closed finisher room	_____
Approximate volume of room (m <sup>3</sup> )	_____
Pigs are moved through the finisher sections following an all-in/all-out system, i.e. sections will be completely emptied, cleaned and disinfected between batches	<input type="checkbox"/> yes <input type="checkbox"/> no

6. Growth/health records

Do you maintain records concerning the growth rates/food intake of the growing herd?      yes ☐      no ☐      (please tick appropriate box)

Please fill in the table below:

	last month	last 6 months
Piglet mortality %		
Grower/Finisher herd mortality %		
Growth rates (g/day) :		
weaners < 45 kg	_____ (g/day)	_____ (g/day)
45 - 90 kg	_____ (g/day)	_____ (g/day)
Food conversion ratio:		
weaners < 45 kg	_____	_____
45 - 90 kg	_____	_____

Thank you very much for completing the survey. If you have any questions concerning the project please call me, Jonathan Amory, on 01952 815323.



APPENDIX 3 – Farm details questionnaire for Pneumonia and Acute Phase protein study (Chapter 7).

ENVIRONMENTAL RISK FACTORS AND PNEUMONIA IN PIGS QUESTIONNAIRE

1. Identification

Name: \_\_\_\_\_

Farm name: \_\_\_\_\_

Address: \_\_\_\_\_

Ph. / Fax: \_\_\_\_\_

Best time to ring: \_\_\_\_\_

How often are pigs transported to the abattoir? (please tick): weekly ☐; fortnightly ☐

Average number of pigs shipped .

Usual day of slaughter (please tick) :

Monday ☐; Tuesday ☐ Wednesday ☐; Thursday ☐; Friday ☐ ; variable ☐.

Approximate time of arrival at abattoir?  Live weight at slaughter

1.1 Number of sows:  Number of grower/finishers:

Weaning age:

Number of production stages after weaning: 1 2 3 4 5 6 (circle)

STAGE	1	2	3	4	5
Age (weeks)					
Weight (kg)					
Mixed? (tick)					
Group size					

2. Location

2.1. Distance to nearest pig farm (miles):

2.2. Distance to nearest pig farm in direction of prevailing wind:

2.3. Number of farms within a 2 mile radius:

### 3. Current herd health status

#### 3.1. Are you using any of the following preventive measures? (please tick)

Vaccination against	<input type="checkbox"/> yes	Vaccination against	<input type="checkbox"/> yes
<i>Mycoplasma hyopneumoniae</i> (enzootic pneumonia)	<input type="checkbox"/> no	<i>Actinobacillus pleuropneumoniae</i> (pleuropneumonia)	<input type="checkbox"/> no

#### 3.2. Have you observed any of the following conditions during the last two weeks? (please tick)

Coughing in piglets up to 20 kg (weaners)	<input type="checkbox"/> yes <input type="checkbox"/> no	Coughing in pigs 45-100 kg (finishers)	<input type="checkbox"/> yes <input type="checkbox"/> no
Coughing in pigs 20-45 kg (growers)	<input type="checkbox"/> yes <input type="checkbox"/> no	Diarrhoea in any age group	<input type="checkbox"/> yes <input type="checkbox"/> no

#### 3.3. Have you been using antibiotic medicated feed or other antibiotic treatments during the last two weeks for any health disorder or as a prevention? (please tick)

in-feed medication of pigs in the grower stage	<input type="checkbox"/> yes <input type="checkbox"/> no	individual treatments of grower pigs by injection	<input type="checkbox"/> yes <input type="checkbox"/> no
in-feed medication of pigs in the finisher stage	<input type="checkbox"/> yes <input type="checkbox"/> no	individual treatments of finishers by injection	<input type="checkbox"/> yes <input type="checkbox"/> no

---

### 4. Management

---

#### 4.1 Please estimate the cleanliness of your pigs (please circle one)

n.b. 0 = very clean (0% skin covered by dung), 10 = very dirty (100% skin covered by dung)

<b>Growers</b>	0	1	2	3	4	5	6	7	8	9	10
<b>Finishers</b>	0	1	2	3	4	5	6	7	8	9	10

#### 4.2 I consider the hygiene status of my farm to be (please tick one)

Good	<input type="checkbox"/>
Adequate	<input type="checkbox"/>
Could be better	<input type="checkbox"/>

#### 4.3 I consider environmental factors (temperature, humidity, air quality etc.) to be important for swine health (please tick one)

Yes, very important	<input type="checkbox"/>	No, not very important	<input type="checkbox"/>
Yes, some importance	<input type="checkbox"/>	No, doesn't make any difference	<input type="checkbox"/>

#### 4.4 I consider the current environment for the pigs on my farm to be: (please tick one)

Good	<input type="checkbox"/>	Could be better	<input type="checkbox"/>
Adequate	<input type="checkbox"/>		

## 5. Housing

### 5.1. Grower pigs (*please tick*)

Ventilation is supported by fans	<input type="checkbox"/> yes <input type="checkbox"/> no
The ventilation is automatically controlled (thermostat)	<input type="checkbox"/> yes <input type="checkbox"/> no
The threshold temperature in the grower pen is set to	°C
Pigs are mostly fed wet feed, e.g. wet-dry feeding	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs have unlimited access to drinking water (ad lib)	<input type="checkbox"/> yes <input type="checkbox"/> no
There is a liquid manure system and slatted floors	<input type="checkbox"/> yes <input type="checkbox"/> no
Effluent is removed	<input type="checkbox"/> daily <input type="checkbox"/> less <input type="checkbox"/> more
Bedding (such as straw, wood shavings) is being used	<input type="checkbox"/> yes <input type="checkbox"/> no
All pen separations are solid (no possibility for nose to nose contact)	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs less than 12 weeks old are sharing room with pigs 5 or more weeks older than them	<input type="checkbox"/> yes <input type="checkbox"/> no
Average size of pen (m <sup>2</sup> )	_____
Average number of pigs per pen	_____
Maximal number of pigs per pen	_____
Average number of pigs per closed room	_____
Maximal number of pigs per closed room	_____
Approximate volume of room (m <sup>3</sup> )	_____
Pigs are moved through the grower sections following an all-in/all-out system, i.e. sections will be completely emptied, cleaned and disinfected between batches	<input type="checkbox"/> yes <input type="checkbox"/> no

### 5.2. Finisher pigs

Ventilation is supported by fans	<input type="checkbox"/> yes <input type="checkbox"/> no
The ventilation is automatically controlled (thermostat)	<input type="checkbox"/> yes <input type="checkbox"/> no
The threshold temperature in the finisher pen is set to	°C
Pigs are mostly fed wet feed, e.g. wet-dry feeding	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs have unlimited access to drinking water (ad lib)	<input type="checkbox"/> yes <input type="checkbox"/> no
There is a liquid manure system and slatted floors	<input type="checkbox"/> yes <input type="checkbox"/> no
Effluent is removed	<input type="checkbox"/> daily <input type="checkbox"/> less <input type="checkbox"/> more
Bedding (straw, wood shavings) is being used	<input type="checkbox"/> yes <input type="checkbox"/> no
All pen separations are solid (no possibility for nose to nose contact)	<input type="checkbox"/> yes <input type="checkbox"/> no
Pigs more than 12 weeks are sharing room with pigs 5 or more weeks younger than them	<input type="checkbox"/> yes <input type="checkbox"/> no
Average size of pen (m <sup>2</sup> )	_____
Average number of pigs per pen	_____
Maximal number of pigs per pen	_____
Average number of pigs per closed finisher room	_____
Maximal number of pigs per closed finisher room	_____
Approximate volume of room (m <sup>3</sup> )	_____
Pigs are moved through the finisher sections following an all-in/all-out system, i.e. sections will be completely emptied, cleaned and disinfected between batches	<input type="checkbox"/> yes <input type="checkbox"/> no

6. Growth/health records

Do you maintain records concerning the growth rates/food intake of the growing herd?      yes ☐      no ☐      (please tick appropriate box)

Please fill in the table below:

	last month	last 6 months
Piglet mortality %		
Grower/Finisher herd mortality %		
Growth rates (g/day) :		
weaners < 45 kg	_____ (g/day)	_____ (g/day)
45 - 90 kg	_____ (g/day)	_____ (g/day)
Food conversion ratio:		
weaners < 45 kg	_____	_____
45 - 90 kg	_____	_____

Thank you very much for completing the survey. If you have any questions concerning the project please call me, Jonathan Amory, on 01952 815323.